An Evaluation of Emergency Medical Disaster Planning for Earthquakes in San Francisco

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June, 1975

AN EVALUATION OF EMERGENCY MEDICAL DISASTER PLANNING FOR EARTHQUAKES IN SAN FRANCISCO

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Funds Provided by Grants from

U. S. Department of Health, Education and Welfare

and

The Robert Wood Johnson Foundation

"The speed with which events follow one another combines with completely unforseen sounds, movement, and awesome sights to produce anxious confusion in all but the most level headed -- at a time when disastrous consequences require heads to be unusually cool and level.

"If there is any one thing to be learned, it is the value of a ready-made plan for coping with such predicaments. The character who can cope with an emergency when it occurs, without preplanning, is admirable and wonderful. However, there are too few of him around when the show starts".

American Hospital Association, Readings in Disaster Preparedness, Chicago, Illinois, 1973, p. 26.

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Part I

Introduction

Our principal task with respect to the matter of disasters has been to examine the current and emergent state of plans and plan implementation within the health care system and the City's utility, transportation and communication systems, given the occurrence of seismic events which result in large numbers of human casualties. This has required us to examine previous and on-going efforts to estimate the consequences of such events and to attempt to identify strengths and weaknesses in the mechanisms available for assessing a given earthquake disaster's scope and character. We have also examined ways of supplying key actors in the emergency response system with the best possible means to locate and organize available health care resources to care for the casualties expected in this kind of disaster.

We wish to stress that we are not proposing to supplant existing plans with one of our own devising. Rather, our purpose is to describe these plans from a particular perspective, to discuss ways in which their underlying assumptions may lead to system weaknesses under crisis situations, and to explore feasible ways of enhancing their likelihood of success under actual post-quake conditions.

Disaster planning in San Francisco has embraced a number of disaster causes other than earthquakes, most notably large fires, major transportation accidents, pollution, flooding and nuclear attack. Whatever the cause, most individuals and groups engaged in planning or implementing disaster response procedures assume a general taxonomy of disaster types extending from extraordinary occurrences of limited scale to cataclysmic events with overwhelming effects on the City's health care system. We too found it useful in our analysis of quake impacts to think in terms of disaster categories that define different magnitudes of impact and different

operational situations affecting the ability of the health care system to provide casualty care.

In our own categorizations, we have tried to stay generally within the four disaster conditions and three emergency response levels defined in the Department of Public Health's General Operational Procedures for Emergency Medical Care, although we have modified and expanded these categories somewhat in order to emphasize those factors most relevant to the adaptive capacity of the health care system. The taxonomy which follows introduces our overall assumptions about disaster types which we found helpful in focusing in detail on emergency medical responses to earthquakes.

Category 1 DISASTER

Events occurring outside the city which do not directly affect emergency health care capacity within the city, but which result in requests for assistance which could result in diverting or consuming resources (e.g., ambulances, supplies, medical personnel, and hospital space). Such outside demand could be expected to reduce the capacity to respond routinely to emergencies developing within the city. This may necessitate alerting or mobilizing backup resources in or near the city. While both private and public emergency health components have regional responsibilities under a variety of mutual aid agreements and licensing requirements, it is the public sector which can and must assess the impact on capacities of various sorts and make the decision to alert or mobilize. A chief concern for type I disasters, therefore, is to provide the means for public health and medical management to accurately and quickly assess the demands for resource diversion and for the clarity and effectiveness of procedures established to give authority to public officials to allocate both public and private emergency health care equipment and facilities. Under some circumstances an event whose casualty effects are felt primarily outside the city will not occasion activation of the city-wide emergency response structure. In such cases, the normal "in-house" capability to get and act decisively on relevant information becomes crucial.

Category 2 DISASTER

Localized events which can be handled within the existing administrative structure of the San Francisco Emergency Medical Services and the Department of Public Health. This type may tax the short-run capacity of the public EMS and may require bringing non-public ambulance and emergency room services into the picture. It would not, however, usually entail

mobilization or conversion or manpower or material resources outside of the health care system. This assumes, of course, that other local government agencies such as police, fire and public works would be involved as the circumstances dictated but that city-wide disaster mechanisms would not be activated. A large concern in events of this type is the adequacy of internal EMS management procedures, the effectiveness of the communications system linking the various responding components, and the level of cooperation routinely afforded each other by these various organizations.

Category 3 DISASTER

Large scale events with major impacts within the city which, while effectively overwhelming the short-run response capacity of the city do not so disrupt the regional communications and transportation infra-structure as to render assistance from nearby areas very difficult. City-wide disaster procedures would invariably be involved, and our concerns here are essentially the same as those we have for type 4 disasters.

Category 4 DISASTER

Catastrophic events with area-wide effects which should be assumed to have very substantially disrupted transportation, communications, energy, water supply and health care infrastructures throughout the Bay counties. As a direct effect of this kind of event, emergency health care capacity will be devastatingly reduced (i.e., through collapse of hospital structures, loss of health manpower, etc.) Hospitalizable casualties in the city will be as high as tens of thousands. Phenomena of mass behavior will make crowd control a problem. Although all resources that can be put under control of the city government will be mobilized to the fullest extent possible, the objective of such efforts will in all probability be confined to stabilization of the progressive effects of the disaster, responding to

the most critical needs, and assessing and communicating the level of need for resources which state and government agencies must be asked to supply. Disasters of this scale almost inevitably will result in supplementation and even supplanting of city functions and resources by military organizations. The period during which emergency response will be the predominant activity within the city will be extended to weeks or months and may well have secondary impacts on the health care system (broadly defined), as hundreds of thousands of citizens evolve and stabilize their own perceptions of the event.

Study Method

We elected to focus our study on the assumptions and projections involved in the event of Category 3 and 4 earthquake disasters (measuring 7.0 and above on the Richter scale). Three premises influenced our decision. First, the scale of these events would appear to test the greatest extraordinary capacities of the health system to organize and provide disaster casualty care. If the city and its surrounding region is "prepared" for a great quake, it should be able all the more to respond to lesser disasters. Second, in San Francisco, a large earthquake is unquestionably the kind of major disaster most solidly imprinted in public consciousness. This public awareness is fostered by the continuing and rather extensive media attention given it, and health care leaders are presumed by the public to have a great moral and professional obligation to minimize the consequences of such an event. Third, scientific opinions appear to be reinforcing the expectations of the public as to the inevitably of dangerous quakes (7.0 or greater) along both the San Andreas and Hayward/Calaveras fault systems. Seismic specialists whom we interviewed differed about the <u>imminence</u> of another large quake and with respect to which of the fault zones passing through

the Bay Area currently is the more dangerous, yet they were unanimous on the issue of inevitability of such events in this area.

The approach we have taken in our study has involved essentially, four kinds of activity:

1. Projections of the effects on the demand and supply of emergency care capability from data developed in earlier studies of seismic risk accruing to the event of San Andreas Quakes of 7 and 8.3 on the Richter scale.

The most important sources in this respect were:

(a) A Study of Earthquake Losses in the San Francisco Bay Area prepared in 1972 by the National Oceanic and Atmospheric Administration (also known as "The NOAA Report");

(b) San Francisco Seismic Safety Investigation prepared in 1974 by John A. Blume & Associates, Engineers, and referred to herein as "The Blume Report".

From both reports we aggregated related data to show the interactive effects of various projections. We also applied distributive coefficients, either contained in the reports themselves or developed by our own analysis, to disaggregate data presented for the Bay Area as a whole (NOAA) or for city subdivisions not corresponding to those currently in use in disaster response planning (both reports).

Also we have tried to make more literal and specific "assumptions for planning purposes" than in earlier reports. For example, we positioned EMS and casualty care facilities on maps showing seismic risk in order to show more graphically the complex of factors affecting access to and use of these facilities. In this respect we have gone beyond the cautious projections of NOAA and Blume Associates, who both chose to avoid indicating

any specific health care structures as being particularly hazardous or stable. We feel that to deny health care managers available data of this sort is an eminently faulty approach to planning. Our purpose in this exercise was also to indicate the need for refining the quality of data on particular health care facilities and the areas they are expected to serve when these facilities, because of existing medical capabilities and locational factors, have been assigned major roles in emergency response plans.

Continuing in this vein we have attempted to synthesize data contained in both the NOAA and Blume reports to estimate hospitalizable casualties by area and to relate these to some admittedly primitive measures of casualty care capacities.

2. Interviews

We conducted two types of interviews with people in the following categories:

(a) Current incumbents or designees of positions with important managerial roles in the casualty care aspects of a major quake disaster:

(1) Director, Mayor's Office of Emergency Services
(2) Director, San Francisco Department of Public Health
(3) Asst. Director, San Francisco Department of Public Health
(4) Medical Society Designee of Chief Medical Care
(5) Superintendent, Public EMS
(6) Hospital Council Designee as Chief Hospital Care
(7) Coroner, City of San Francisco

In these interviews we attempted to draw out the respondents' ideas and perceptions on three broad kinds of issues.

(1) The kinds of preparatory work and thinking each had done regarding his role in a major quake disaster

(2) Construction of a scenario as to how each respondent personally visualized the events and actions following the quake

(3) A set of questions to which each respondent had as yet developed or received no satisfactory answers which he nonetheless viewed as critical to the effective accomplishment of his designated disaster response role.

(b) Persons currently or recently involved in disaster planning for San Francisco at Local and Regional levels.

(1) Medical Coordinator, Office of Emergency Services
(2) Principal Author - Community Safety Plan, Department of City Planning
(3) Program Manager, San Francisco Seismic Safety Investigation, John A. Blume & Associates, Engineers
(4) Chairman, San Francisco Hospital Council, Disaster Planning Sub-Committee
(5) Director, Emergency Medical Services, Hospital Council of Northern California
(6) Sr. Planners (disasters), Association of Bay Area Governments
(7) Asst. to Principal Investigator and Principal Consultant "NOAA" study (phone interviews)
(8) San Francisco Department of Public Health, EMS Training Director
(9) San Francisco Department of Public Health, EMS Planner
(10) Asst. to Deputy Chief (Engineering) San Francisco Toll Bridge Office, CALTRANS
(11) Seismic Researchers at U.S.G.S. (Menlo Park), U.C. (Berkeley), La Mont Geophysical Laboratory, Columbia University
(12) Regional Coordinators, California State Department of Health, Emergency Medical Services
(13) Radio Specialists, San Francisco Department of Electricity
(14) Emergency Telephone personnel, Pacific Telephone Company
(15) Deputy Chief for Operations and Engineering, Municipal Railway
(16) Several Red Cross personnel concerned with specific aspects of mass and casualty care

These interviews were designed to obtain the most candid views possible as to the state of plan development implementation and to obtain documents and related written materials to use as background materials.

3. Analysis of Quake Impacts

In the course of interpreting the results of our study, we divided our analysis into eight sections, each constituting a major heading in Part II of this report. These are:

(1) Damage to Major Hospitals

(2) Casualties

(3) Post Earthquake Supply and Demand for Hospital Beds

(4) Assembly of Needed Casualty Care Personnel

(5) Communications and Situation Assessment Capacity

(6) Transportation for Casualty Care

(7) Medical Supplies and Equipment

(8) Care of the Dead

4. Recommendations

Part III of the report interprets the findings developed through Part II and summarizes evaluative issues for which recommendations are directly rooted in the results of the inquiries we made in some detail. We have also included some comments in this section regarding the closely related matters of mass behavior, crowd control and public education. We asked some questions and read some materials on these topics but lacked the time to adequately follow up on aspects which we felt needed considerable further examination.

Part II Analysis of Quake Impact

1. Damage to Major Hospitals

The NOAA study employed structural engineers to make field inspections of all 22 major San Francisco hospitals (over 100 beds) in 1971. Because of several adverse findings, these hospitals were predicted to suffer a huge 63% loss in beds available for all types of medical care as a result of damage inflicted by an 8.3 earthquake on the San Andreas fault. (NOAA, Tables 18 and 22). First, half of San Francisco's major hospitals in 1971 contained portions that were built prior to 1933 before any lateral force design requirements were legislated and three of these were of unreinforced brick construction, a building type that performs very poorly during large earthquakes. Second, sixteen San Francisco hospitals were from 5 to 8 stories high; those that would be heavily damaged would have to generally evacuated even if they did not collapse, and several others would be very likely to lose all elevator services, necessitating partial evacuation. Third, electrical systems in hospitals after an 8.3 quake would rely wholly on auxillary power generators, which typically do not cover lighting and equipment for all areas of a hospital. Some hospitals would be forced to leave beds empty despite unfilled needs throughout the city because they would be in rooms that are unlit or disconnected from critical equipment.

Because the NOAA report protected the identity of all hospitals studied, in order for us to distribute these total expected bed losses from an 8.3 San Andreas earthquake to particular hospitals in San Francisco, it was necessary to make detailed extrapolations from the building damage, geological and earthquake hazard maps presented in the study of John Blume

& Associates. Blume's 1974 report to the city assigned one of four degrees of estimated building damage to each block in San Francisco, based on an analysis of building type statistics in the City Assessor's Office and of U.S. earthquake damage history in relation to building type. Considerable weight was given to San Francisco-1906 and San Fernando-1971 post-quake building performances. The categories of damage were as follows:

Severe	Extensive to complete damage of nonstructural elements, and structural damage ranging from heavy to essentially total in some cases. Some collapses and many buildings for which replacement would be more economical or desirable than repair. There would also be damage as described for the lesser categories.
Heavy	Heavy damage to architectural and other non-structural elements and materials. Structural damage extensive. Some structures out of plumb. There would also be damage as described for the lesser categories.
Moderate	Damage to many nonstructural elements and materials, partitions, walls, stairways, chimneys, etc. Some Structural damage but not in all cases. There would also be damage as described for the slight category.
Slight	Some cracked and damaged walls, partitions, stairways. Broken chimneys. Parapets and ornamentations dislodged. Structural damage generally minor, if any.

(Blume, pp. 70-71)

The degree of damage assigned to each block was computed by <u>averaging estimated damages</u> among that block's buildings; therefore, the Blume study warned against making any inferences about particular buildings without an engineer's site investigation.

Nevertheless, the extensiveness of hospital bed losses predicted by NOAA and the massive casualties resulting from an 8.3 San Andreas day-time quake predicted by both NOAA and Blume compel us to at least <u>suggest</u> which hospitals in San Francisco are on risky ground <u>or</u> in a block that

will be damaged according to Blume's detailed maps. Furthermore, some hospitals are very large buildings and an obviously great part of their particular block; in such cases, our extrapolations are more certain.

We located the 22 major hospitals, the Department of Public Health's emergency aid stations, and those district health centers that are official casualty care facilities in the event of a city wide disaster on Blume's "A" map of expected building damage due to a 1906-type quake.

ESTIMATED BUILDING DAMAGE LEVELS FOR A "1906 TYPE" EARTHQUAKE

In addition, we investigated these facilities' positions on Blume's maps of estimated geological stability, estimated earthquake ground shaking, areas of major potential liquifaction hazard, potential landslide hazard, and areas of major potential subsidence hazard. The following institutions appear to be likely recipients of moderate or greater damage as categorized by Blume. It seems reasonable also to infer that they constitute a significant portion of the overall 63% loss in useable major hospital beds predicted by NOAA.

Severe Damage	Chinese Hospital, Golden Gate Hospital (recently closed), Central Emergency Hospital
Heavy Damage	Shriner's Hospital and District IV Health Center
Moderate Damage	San Francisco General Hospital (old structures), St. Luke's Hospital, St. Francis Hospital, Laguna Honda Hospital, Cathedral Hill Hospital, and District I Health Center

It is important to remember that the huge loss of useable hospital beds in San Francisco posited by NOAA included the effects of disruptions or reductions in hospital internal communications, elevator service, and electricity, in addition to the effect of damages to building structures. Although at this time we cannot attribute these other losses to particular hospitals, for planning purposes the Department of Public Health should assume that other hospitals besides those listed above are as likely to face reduced capacity as those that we have suggested to suffer bed losses due to average damage levels on the blocks in which they are situated.*

Furthermore, it is important to note that with an 8.3 shock on the San Andreas fault, the NOAA study projects very high bed losses also in neighboring San Mateo, Marin and Santa Clara Counties. In San Mateo, 2,713 of

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*At least those hospitals associated above with heavy or severe damage following an 8.0 scale quake would benefit from either (a) new seismic safety investigations or (b) governmental action to obtain the individual site engineering reports developed by the NOAA study

3,466 major hospital beds would be unavailable; in Marin County, 380 of 594, and 4,527 of 6,720 beds would be unusable in Santa Clara. And Alameda County would lose about a fifth of its available capacity--1,265 of 6,107 major hospital beds. (Tables 18 and 22) As we will demonstrate in a later section, Bay Area capacity to absorb just San Francisco's ex post hospital bed demand will not be forthcoming after this size daytime San Andreas earthquake.

With earthquakes of lesser magnitude than 8.3 on the San Andreas fault, or with an 8.3 on the Hayward Fault, San Francisco's hospitals will be inflicted by much lighter losses. After a 7.0 San Andreas shock, NOAA predicts San Francisco will lose 947 major hospital beds (10% of capacity) and with an 8.3 quake on the Hayward Fault, the prediction is for a loss of 404 San Francisco beds (4%). (Table 22) In these contexts, obviously the major hospitals of San Francisco will be in stronger post-earthquake condition to cope with the demands for hospitals beds resulting from injuries to persons within county limits. However, hospital damages that generate bed losses in Alameda, Santa Clara, Contra Costa, and San Mateo counties after a daytime 8.3 Hayward Fault earthquake would completely exhaust all the vacant capacity remaining in San Francisco, according to the model of post-earthquake supply and demand for hospital beds that we compute below.

2. Casualties

Estimating deaths and injuries for any large metropolitan area that experiences a major daytime earthquake is complicated by the enormous variety of locations in which the inhabitants will be diffused, the diverse age and other qualities of the structures they are in or adjacent to, and the speed with which daytime activities and locations change for many persons.

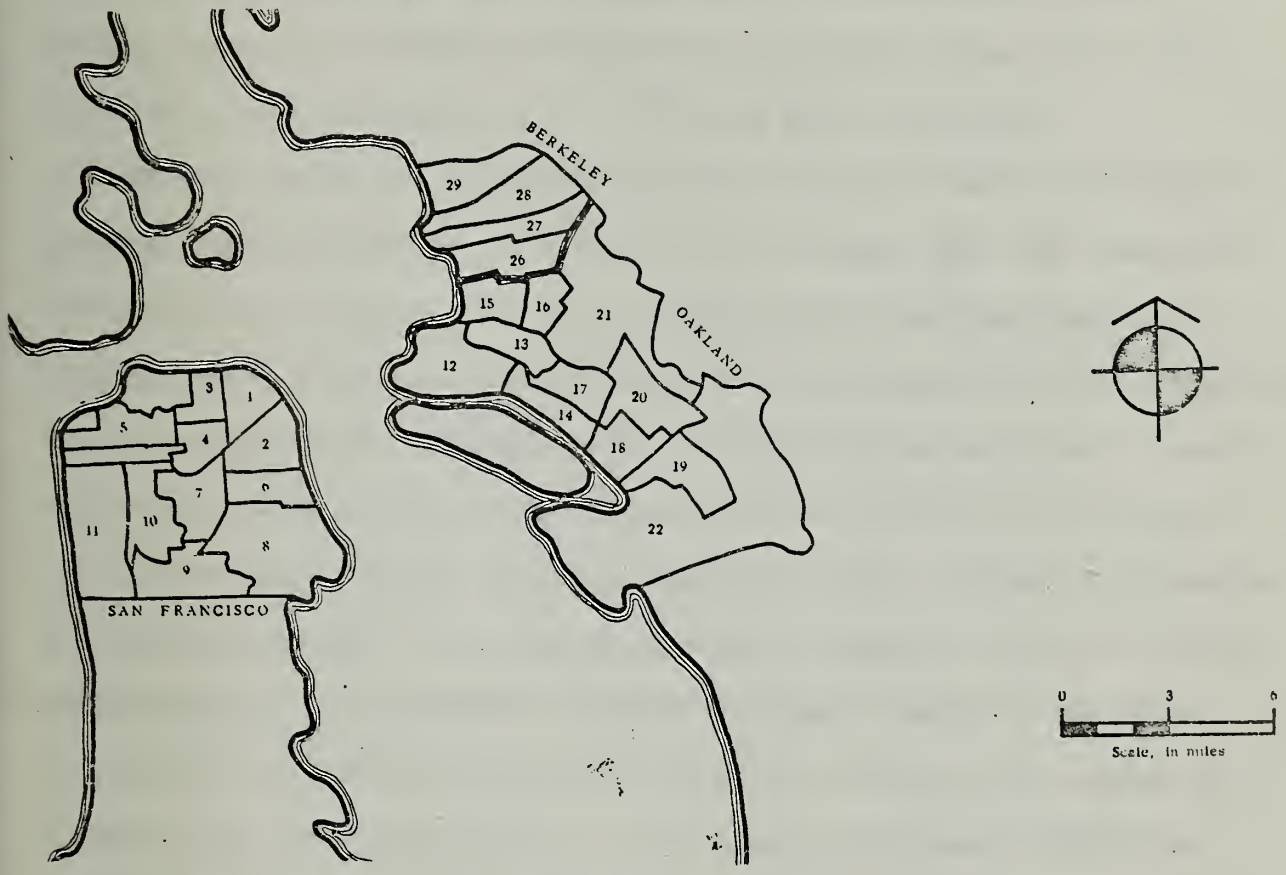
As the NOAA study points out, it is considerably easier to figure casualties resulting from an earthquake in the middle of the night, both because the location pattern is simpler than -- with a large majority of inhabitants being in their residences -- and because earthquake casualty history is older and more reliable for most residential type structures than it is for modern American freeways, skyscrapers, rapid transit, or even hospitals. Nonetheless, the experts who worked on the NOAA and Blume studies developed several pragmatic methods to estimate daytime casualties which we have extended to generate a range of estimates of the seriously injured that the San Francisco health care system can expect.

a. The NOAA approach to casualties

NOAA computes expected Bay Area deaths and casualties for a 2 p.m. 8.3 San Andreas quake by (a) portioning the population into general building types; (b) applying risk factors due to older construction, size of buildings, percent of population in congested multistory areas, freeway collapse and other transportation accidents, falling parapets, glass and ornamentation; (c) projecting specific estimates of casualties for unsafe schools and hospitals. These factors are combined to produce an overall estimate of 9,460 deaths and 34,400 serious injuries that require hospitalization for the nine Bay Area counties.

In order to disaggregate this projection, we calculated San Francisco's proportion of the estimated Bay Area casualties for each of the major risk coefficients computed by NOAA. Thus, for the 600,000 persons in the Bay Area's congested areas, we estimated conservatively that San Francisco county would suffer 2/3 of the total 3000 deaths estimated, since San Francisco had a peak daytime population of 284,076 in 1970 in its downtown

finance, retail, and civic center districts and well over 100,000 persons in its wholesale trade district south of Market Street. With NOAA's assumption of 4 serious injuries to 1 death, our estimate for this area became 2000 deaths and 8000 serious injuries.



(NOAA report, p. 112. Zone 1 San Francisco population = 284,076, Zone 2 San Francisco population = 169,997. Source: Statistical Abstract, Four County Shelter Plan, Association of Bay Area Governments, 1970 Census figures.)

Subtracting the 400,000 persons placed in San Francisco's high risk congested areas from the city's total daytime 1970 population of 959,108 left 599,108 persons who would be subjected to various other casualty rates. Following NOAA's approach, we divided this remainder in half and subjected one part to the hazard equivalent of nighttime casualty expectations and the other part to a slightly higher hazard. This gave San Francisco 319,554 persons, or 16% of the 2 million daytime Bay Area

inhabitants, experiencing each of these two hazards; we computed the city's 16% of the NOAA totals for the Bay region. Our result was an expectation of 160 deaths and 640 serious injuries among those experiencing the nighttime equivalent risk and an estimate of 166 deaths and 664 serious injuries for persons affected by the slightly higher risk, which was based on the casualties of the 1933 Long Beach earthquake.

In addition to the casualties attributed above to the risks of general building types and density differences in the region, NOAA also quantified certain specific hazards. First, we noted earlier that San Francisco's hospitals were field inspected by NOAA engineers who predicted the structural damage the system of 1972 would suffer. The casualties expected to result from these damage estimates were figured for San Francisco as 555 deaths and 2,874 serious injuries requiring hospitalization. Second, NOAA reported that falling masonry, brick, and glass would average one death per building over 4 stories that had brick or masonry facings, veneers, or parapets. According to the insurance industry statistics utilized in the study, San Francisco had 800 such buildings. This hazard would generate 800 more deaths and 3200 more serious injuries under NOAA's assumptions.

Third, 200 deaths from freeway collapse and other ground transportation accidents due to a 2 p.m. 8.3 San Andreas shock were predicted for San Francisco and Oakland. We halved this estimate, to posit 100 deaths and 400 serious injuries from these causes for San Francisco alone. Also, we mapped some of the likely points where freeways will collapse in the event of such a catastrophe by overlaying major thoroughfares in San Francisco county onto the Blume study's maps of estimated intensity for ground shaking, landslides, subsidence, and liquefaction. And fourth, NOAA revealed that in 1971, 62 out of 197 schools in San Francisco had one

or more buildings which did not comply with California Field Act requirements for earthquake safety, and serious damage and partial collapse of 25% of these unsafe schools was likely with a great earthquake. NOAA estimated 1500 deaths and 4000 injuries requiring hospitalization within San Francisco's educational system (Table 57, p. 193)

In summary, our effort to disaggregate NOAA's Bay Area study consistently for San Francisco County yields the following portrait of expected casualties with a 2 p.m. 8.3 San Andreas quake:

Hazard	Deaths	Injuries requiring Hospitalization
400,000 population in congested areas: 400,000 x 500 deaths/100,000)	2000	8000
319,554 population with equivalent nighttime hazard: 319,554 x 50 deaths/100,000	160	640
319,554 population with twice the 1933 Long Beach hazard: (319,554 x 52 deaths/100,000)	166	664
Hospital damage hazards	555	2874
Falling masonry, brick, and glass	800	3200
Freeway collapses and other transportation hazards	100	400
School damage hazards	1500	4000
Total	5281	19,778

b. The Blume approach to casualties

Blume's study, prepared for the San Francisco Department of City Planning in June, 1974, focused singularly on the county of San Francisco. The main goal of Blume's research was to investigate the seismic safety of buildings in different areas of the county. In approaching this goal,

Blume produced detailed maps of San Francisco's geological and building hazard risks (see our page 12), among which was the "A" map of degrees of expected building damage in the event of a 1906 type earthquake.

ESTIMATED BUILDING DAMAGE LEVELS FOR A "1906 TYPE" EARTHQUAKE

Blume's study did not compute the expected deaths and serious injuries that would be associated with the distribution of structural damage shown on the above map. However, it did propose casualty coefficients that correspond with the degrees of damage projected and it suggested that with census tract data on population deployment at various times of the day and days of the week, rough estimates of deaths and hospitalized injuries from building damage could be made. In the following paragraphs, we will concretize the Blume approach to estimating casualties in a way that also attempts to provide a basis for comparison with the results we derived from NOAA.

In order to relate the two studies, we decided to use the same population statistics that NOAA incorporated and to apply Blume's casualty coefficients to this common base. Implementing this approach involved several steps. First, we obtained a large version of Blume's estimated building damage map and demarcated it by the eleven peak daytime districts used by NOAA, shown on page 16 of this report. This gave us bounded areas with estimated populations and degrees of building damage marked for the blocks within each area.

On the portion of Blume's building damage map found below, the large numbers and heavy lines show all of the most intensely impacted population districts. The thinner lines and five digit numbers on this map are zip code zones, used by the San Francisco Office of Emergency Services to advise the public on the location of disaster care facilities.


94123
Bay Street
Lombard Street
Columbus Avenue
94133
94129
Doyle Drive
109
Embarcadero St
94115
Arguello Boulevard
Geary Street
94118
Oak Street
94117
Central Skyway
94102
16th Street
7th Avenue
94114
94110
Southern Embarcadero Freeway
3rd Street
Army Street
94131
Portola Drive
94127
Southern
94112
Ocean Avenue
Lower Hts
Geneva Aven
94134
94112

Second, we estimated for these most heavily damaged districts what proportion of area was occupied by each of the shading types that depict various intensities of building damage. The six worst damaged districts were #1,2,3,4,6, and 8. Third, we extracted the casualty coefficients that Blume proposed to be associated with different intensities of damage:

Damage Class	Deaths	Injuries Requiring Hospitalization
Severe	1.0%	15%
Heavy	.3	4
Moderate	.1	1
Slight	.02	.2

(Source: Blume, p. 90)

And fourth, we computed the total deaths and hospitalized injuries for each of the six selected districts by applying Blume's casualty coefficients to the proportions of each district that were marked for each damage class. The following table portrays and summarizes our results.

District	Population	Damage Proportion		Death Rate	Deaths	Injury Rate	Serious Injuries
1	284,076	Severe	.5	1.0%	1420	15%	21,305
	"	Heavy	.25	.3	213	4	2,840
	"	Moderate	.25	.1	71	1	284
	Subtotal				1704		24,429
2	170,000	Severe	.5	1.0	850	15	12,750
	"	Heavy	.3	.3	255	4	3,400
	Subtotal				1105		16,150
3	70,606	Moderate	.25	.1	18	1	177
	"	Slight	.75	.02	11	.2	35
	Subtotal				29		212
4	74,266	Severe	.1	1.0	74	15	1,114
	"	Heavy	.2	.3	45	4	594
	"	Moderate	.2	.1	22	1	149
	"	Slight	.5	.02	7	.2	74
	Subtotal				148		1,931

District	Population	Damage Proportion	Death Rate	Deaths	Injury Rate	Serious Injuries
6	49,109	Severe .1	1.0	49	15	736
	"	Heavy .2	.3	30	4	392
	"	Moderate .2	.1	10	1	98
	"	Slight .5		5	.2	49
	Subtotal			94		1,275
8	99,773	Severe .1	1.0	90	15	1,347
	"	Heavy .2	.3	54	4	718
	"	Moderate .2	.1	18	1	180
	"	Slight .5	.02	9	.2	90
	Subtotal			171		2,335

Total Blume Estimates For Most Damaged Areas of San Francisco:

3,251 Deaths
46,332 Hospitalized Injuries

c. The range of casualties expected with a 2 p.m. 8.3 San Andreas earthquake

The two approaches to casualty projection that we have utilized establish a range for major demands on health and medical services after such a disaster. At the same time, obviously they do not indicate all of the likely claims on the system. For one thing, a massive source of additional demands will arise from the many thousands of persons inflicted by minor injuries that need not result in hospitalization. Secondly, both study approaches can only serve as the basis for predicting general demands on medical and health resources--e.g., hospitals beds for the injured, transportation and burial of the dead--because they do not delineate the expected requirements of specific medical and health emergencies that are likely to occur as a result of a great quake. Further study clearly is necessary if city leaders desire to anticipate both the scale and distribution of any such particular emergency and the resources that must be controlled to be ensured of an adequate response to it.

The two projections that we have computed thus far warrant some comparison. Let us first review their ultimate differences. Our disaggregation of NOAA to find San Francisco's share of the estimated casualties for the Bay Area produced 5,281 deaths and 19,778 hospitalized injuries; whereas, our application of Blume's analysis to the same population base used by NOAA produced 3,251 deaths and 46,332 hospitalizes injuries. The most powerful reason for the large difference in serious injuries predicted by these two computations appears to be the assumptions that each earthquake study made about injury/death ratios. To wit, NOAA reports on page 118 that hospitalized injuries will average around 4 times the deaths precipated by an 8.3 quake, and our results are quite near that ratio; on the other hand, Blume assumes explicitly that injuries requiring hospitalization will range from 10 to 15 times deaths in such a disaster--increasing with higher intensities of building damage--and our projection based on Blume's analysis also is quite near the upper end of this interval, about 15 serious injuries to 1 death.

The differences in estimated deaths are not as easily explained, although two influences clearly are at work. One, our application of the Blume approach was limited to figuring deaths due to building damage and the associated risk of falling materials. Blume developed geological maps of San Francisco showing the likely distribution of other hazards--including ground instability, subsidence, liquefaction, land-slides, reservoir innundation, and tsunamis--but the study did not quantify the loss of life that was expected to occur with their incidence. By comparison, NOAA was more complete because it predicted losses from other factors beside building damage--transportation related deaths, for instance.

Second, using the Blume approach, we found an insignificant number of deaths located outside the six heaviest damage areas that were selected

for detailed analysis. Although there were scattered blocks marked for strong damage in the other districts, and a few of these blocks contained schools and hospitals, Blume's study approach minimized these other losses because it depended entirely on the area proportions for damage intensities within large population districts. In contrast, using NOAA's approach provided us with specific data on the substantial expected loss of lives in San Francisco's schools and hospitals by methods that were independent of the structural safety of these institutions' surrounding areas. If one subtracts these hospital and school deaths from NOAA's total human losses, the result is quite near the total deaths we estimated in applying Blume's methodology.

In conclusion, we respect the projective value of both estimates as the empirical judgments of top national and international earthquake experts. We know also that the task of earthquake casualty prediction for a city like San Francisco is particularly difficult because of the complexity of the physical environment and human activity patterns here that can result in these unfortunate outcomes. Both these considerations lead us to the argument that a range of expected casualties for an 8.3 San Andreas earthquake during the afternoon is the fairest bet and the most realistic approach for medical disaster planning. In later sections of this report we will analyze the capability of health and medical earthquake responses to these intervals of casualty loads: <u>for deaths, from 3,251 to 5,281; for hospitalized injuries, from 19,778 to 46,332</u>.

d. <u>Casualties from a 7.0 San Andreas earthquake</u>

Much less concern has been voiced and written about the life-endangering consequences to San Franciscans of smaller than catastrophic sized quakes.

The Blume study, which serves as the official basis for the city's proposed Community Safety Plan, made no predictions at all about casualties due to any shock along the San Andreas fault near San Francisco which was less than 8.3 on the Richter Scale. The single source of predictive data about casualties from earthquakes below this 1906-type magnitude that we have found was NOAA's report on the whole Bay Area.

Unfortunately, the NOAA study did not explicate its methodology for scaling down casualties with reductions in earthquake magnitude. Apparently the hazards that were incorporated in its analysis of an 8.3 quake simply were adjusted by a logrithmic factor to reflect the author's views of earthquake casualty history. In any event, the lack of a detailed analysis of the components of Bay Area casualties with a 7.0 earthquake meant that the only method for disaggregating NOAA's figures for casualties that was available to us was to apply a total Bay Area/San Francisco ratio for different sized quakes.

We did this, as follows. With a 2 p.m. San Andreas shock of 8.3, NOAA predicts 9,460 Bay Area deaths and 34,400 Bay Area hospitalized injuries; with a 2 p.m. 7.0 quake along the same fault, NOAA estimates 1640 deaths and 6200 hospitalized injuries. The reduction in San Francisco's deaths with a 7.0 earthquake thus was computed by this equation:

$$\frac{9460^{8.3}}{1640^{7.0}} = \frac{5281^{8.3}}{X^{7.0}} \qquad \text{(from p.18 of this report)}$$

$$X = \underline{915.5 \text{ San Francisco deaths}}$$

And the reduction in San Francisco's hospitalized injuries with a 7.0 quake was figured similarly:

$$\frac{34400^{8.3}}{6200^{7.0}} = \frac{19778^{8.3}}{Y^{7.0}}$$

$$Y^{7.0} = \underline{3564.6 \text{ San Francisco hospitalized injuries}}$$

By NOAA's estimates, when an earthquake's magnitude falls to 6.0 on the Richter Scale, this event will generate under 300 serious casualties in San Francisco; consequently, it will be a Category I disaster for the health system.

3. The Post-Earthquake Supply and Demand for Hospital Beds

Because hospitals ordinarily are expected to play a critical role in reducing the loss of life and serious disabilities associated with major disasters, and they are heavily relied on as casualty care centers in San Francisco's general disaster planning framework, we became especially interested in discovering the extent to which they would be capable of fulfilling this commitment after a great quake. In order to answer this question with an explicitly reasoned estimate, a model of post-earthquake supply and demand for hospital related services was needed.

We started with the supply assumption that health planning and administrative agencies usually make, as did NOAA, that the best readily available general indicator of hospital capacity for casualty care is the number of beds that can be made accessible to service the seriously injured. For an estimate of pre-earthquake capacity that was consistent with the other parts of this report, we decided to use the bed totals for major hospitals in San Francisco that NOAA generated from California Department of Public Health and Association of Bay Area Governments' sources (NOAA, p. 35) This was 9454 beds in 22 hospitals as of 1971. For estimates of the bed loss in hospitals due to an 8.3 and a 7.0 daytime San Andreas quake, we used figures from our earlier section, "Damage to Hospitals,"

which was based on NOAA's field studies. This loss was 5970 beds after an 8.3 event and 947 beds after a 7.0 shock.

To this supply account, we then added the beds known to be available in other officially designated casualty care centers, which at most was 100 beds. Last, we reduced these supplements to hospital bed capacity by the same bed loss rate as predicted for San Francisco's major hospitals: by 63% with an 8.3 quake and by 10% with a 7.0 quake.

In order to estimate the demand for San Francisco's capacity of casualty care beds, we began by totalling the number of hospital beds that would be already occupied when the disaster struck. This was recently 72.5% of the city's total hospital capacity, based on the average occupancy rates given by one half of San Francisco's major hospitals which responded to a 1975 survey of the California Hospital Conference. Next, we estimated two components to be deducted from this pre-earthquake demand for beds: a loss of bed demand due to patient deaths resulting from the earthquake, and a reduction in bed demand due to the removal of patients who could be safely discharged. For the first deduction, we used NOAA's report of 167 hospital patient deaths following an 8.3 2 p.m. San Andreas quake and 24 deaths after a 7.0 event. For the second, we averaged the estimates of 10 hospitals which responded to a special disaster survey conducted by the Northern California Hospital Conference. This second deduction was 35% of the total number of pre-earthquake occupied beds.

Then we derived two further sources of post-quake demand. We projected the number of additional beds that would be required to serve non-patient serious injuries that would occur inside hospitals, which by NOAA's study amounted to 2012 with an 8.3 daytime quake and 717 with a 7.0 quake. And

we estimated the number of beds required for the thousands of new serious injuries that would result outside hospitals throughout the city. For this latter factor, we employed both the Blume and NOAA approaches to casualties, given in the previous section of this report as producing 46,300 and 19,778 serious injuries respectively with an 8.3 quake. However, NOAA's total of 19,778 injuries included those in major hospitals, so to avoid double counting, we subtracted all in-hospital serious injuries. This yielded an ultimate outside-hospital demand of 16,904 beds.

With a 7.0 daytime earthquake, only NOAA figures were available; the same procedure as above generated 3565 - 1024 = 2541 new outside-hospital serious injuries. However, we must caution health administrators and planners in San Francisco against over reliance on this single estimate of outside-hospital demand when planning and allocating resources for a 7.0 San Andreas shock generally a Category 3 disaster. The Blume approach to casualty estimation for an 8.3 quake predicted a total of serious injuries in the city that was 2.3 times the figure we produced using NOAA's approach. To preserve a margin of safety in the earthquake responses that the health system should anticipate, we strongly suggest a figure of twice NOAA's 7.0 outside-hospital bed demand should be projected beside this lower estimate. We have done this below in the model that follows our explanation of methods.

a. Post-quake demand

By the approach described above, an equation of post-earthquake demand for hospital beds was postulated as,

$$D_q = BO_o - PDH + NPIH + \begin{bmatrix} BPI \\ or \\ NPI \end{bmatrix} - PSR$$

where,

BO_o = Bed occupancy prior to quake

PHD = Patient deaths in hospitals due to quake

NPIH = Non-patient injuries in hospitals resulting from quake

BPI = Blume estimate of injuries requiring hospitalization outside of hospitals

NPI = NOAA estimate of injuries requiring hospitalization outside of hospitals

and PSR = Patients safely removed from hospital beds.

b. Post-quake supply

The equation for the post-earthquake supply of beds was posited to be,

$S_q = (BN_o + BCC) - (BLQ + LBCC)$

where,

BN_o = Total hospital beds prior to quake

BCC = Beds prior to quake from non-hospital casualty care facilities

BLQ = Bed loss in hospitals due to quake

and LBCC = Loss of beds in non-hospital casualty care facilities.

c. The net availability of hospital beds after an 8.3 2 p.m. San Andreas quake

The net surplus or deficit of casualty beds in San Francisco after a repeat of a 1906 type quake can now be calculated, alternatively using Blume and NOAA casualty estimates in the foregoing demand equation. The equation for net availability is,

$N_q = S_q - D_q$.

So, N_q with Blume's assumptions,

$= (BN_o + BCC) - (BLQ + LBCC) - (BO_o - PDH + NPIH + BPI - PSR)$

$= (9454 + 100) - (5870 + 63) - (6854 - 167 + 2012 + 46300 - 2399)$

$= 9554 - 6033 - 52600$

$= -49,079$

And N_q under NOAA assumptions,

$= 9554 - 6033 - (6854 - 167 + 2012 + 16904 - 2399)$

$= 9554 - 6033 - 23204$

$= -19,683$

When one also considers that total Bay Area hospital bed capacity was 35,127 in 1971 as reported by NOAA, plus (a) over one half of this capacity would be lost after an 8.3 San Andreas shock, and (b) one half of the remainder would be occupied with patients who were not subject to safe removal (based on a 72% occupancy rate, of which 35% could be safely removed), both of our projections imply a need for extraordinary health and medical coordination. To wit, either a large number of San Francisco's casualties will have to be transported outside the region--as well as within it--to receive hospitalized casualty care, or they will have to be treated in newly organized facilities established during a post-quake recovery period. Certainly, a mixture of strategies will be possible and desirable. However, at the present time, the possibilities for creating ad hoc casualty treatment centers in San Francisco appear to be limited to whatever the military services can fly or ship into the area. This conclusion is based on the fact that although there were 35 Packaged Disaster Hospitals with emergency medical supplies and bed supply putatively intact according to the NOAA study, none of these 7000 additions to bed capacity were pre-positioned in San Francisco County.

d. The net availability of hospital beds after a 7.0 2 p.m. San Andreas quake

Carrying out the same procedures as before, our calculation of the net availability of hospital beds in San Francisco after a 7.0 daytime quake was as follows:

$$N_q = S_q - D_q$$

with NOAA assumptions

$= (BN_o + BCC) - (BLQ + LBCC) - (BO_o - PDH + NPIH + NPI - PSR)$

$= (9454 + 100) - (947 + 10) - (6854 - 24 + 717 + 2541 - 2399)$

$= 9554 - 957 - 7689$

$= + 908$

However, since this surplus of beds derives from a conservative estimate of casualties when compared to the casualty rates used in the Blume study of San Francisco, we also projected net availability based on twice the above number of ourside-hospital serious injuries.

$N_q = S_q - D_q$

with Blume related assumptions

$= 9554 - 957 - (6854 - 24 + 717 + 5082 - 2399)$

$= 9554 - 957 - 10230$

$= -1,633$

The implication of both estimates is that San Francisco's hospital system will be taxed to the limit of its general capacity after a daytime 7.0 San Andreas quake, but the system may be able to absorb and handle all or nearly all of the seriously injured persons within the county. To do so will require a very efficient logistical effort in the disaster operations that follow this scale of event. The smooth flow of casualties to particular hospitals will involve a continuous updating of the capacity of each hospital to treat the injured, a triage system to carefully sort casualties not requiring hospitalization to other facilities, a massive vehicle mobilization to effectuate thousands of trips to and among the hospitals in a few days, an equally large mobilization of medical personnel and supplies to provide 24 hour treatment for the injured, and many other extraordinary levels of accomplishment. In the remaining sections of Part II,

we will analyze earthquake impacts on some of the crucial subsystems that are needed for an effective overall health and medical responses.

4. Assembly of Needed Casualty Care Personnel

a. Personnel losses inside hospitals

An 8.3 daytime quake would occasion considerable loss through death and injury to personnel working in hospitals. Further, since it is these people who have the casualty response skills most likely to be needed following such a quake, these losses would have a damaging effect on the immediate citywide response to all casualties.

NOAA developed distributive percentages for application to overall estimates of in-hospital deaths and injuries. We applied these to produce the following table:

Medical Personnel Losses Within Hospitals

	Daytime Deaths		Nightime Deaths		Daytime Injuries		Nightime Injuries	
	8.3	7.0	8.3	7.0	8.3	7.0	8.3	7.0
Physicians	9	2	5	1	43	21	25	9
Nurses & Related Staff	344	49	64	9	1782	282	332	119

Source: NOAA report, p. 48

Clearly, a daytime 8.3 quake would result in major organizational problems. The higher casualty rates projected by NOAA for non-physician personnel presumably reflect the greater likelihood that such personnel will at any one time be within the walls of hospital structures subject to some degree of collapse. Logically, these same higher rates should be applied to physician specialities such as radiology and pathology subject to similar exposure. We independently obtained a rough estimate of the average number of pathology staff likely to be in San Francisco hospitals during a typical daytime shift. This estimate included 150

physicians plus an additional 260 non physician technologists, technicians and clerical support personnel.* Applying the "worst case" daytime, non-physician death and injury rates to the combined radiology and pathology estimate results in projections of 9 deaths and 44 injuries to these two groups of physicians alone. The almost exact correspondence between these two figures and the overall estimates for in-hospital physician casualties is probably coincidental, given the roughness of the estimate of total numbers. However, we believe it safe to suggest that these two departments, which will have vital roles to play in a quake disaster, will suffer disproportionate losses of personnel.

Finally, we had no opportunity to disaggregate the non-physician casualties among nurses, orderlies, social workers, maintenance personnel, etc. However, if nurses were assumed to make up 40-50% of the estimated 2126 daytime deaths and injuries among non-physician hospital staff, the nursing losses would be in the range of 850-1050. It is safe to assume that this would occasion a devastating effect on many hospitals' capacity to function and would necessitate a much greater concern with obtaining additional nurses and other needed non-physician personnel than has been evidenced to date.

We should also note that several of the key disaster health care officials have regular posts of duty in locations with above average to severe exposure to structural collapse. Since the formal assigment of responsibility in the city's disaster response plan is quite hierarchial, and the skills and knowledge accruing to posts at each echelon are not, strictly speaking, interchangeable, some organizational and communications problems are certain to arise should any key actor become a casualty.

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*Our source, which we regard as "authoritative" wishes to remain anonymous.

b. Health Care Personnel Losses Outside of Hospitals

NOAA's estimates for health care personnel casualties outside of hospitals are even less precise than those for in-hospital losses. For example they do not differentiate between daytime and nightime quakes. The report contains projection rates of deaths/100,000 of health "manpower" at non-hospital locations throughout the bay. Applying NOAA's algorithm to estimates of physicians present in San Francisco during daytime hours on a week day, we can project an order of magnitude for these losses as follows:

	Earthquake Deaths		Earthquake Injuries	
	8.3	7.0	8.3	7.0
Physicians	6-10	1-3	24-100	4-16
Non-Physicians	10-15	2-4	40-200	8-35

c. Demand for Particular Health Care Specialties

We reproduce here (in revised order) NOAA's table obtained from the Hospital Council of Southern California showing the distribution of casualty types encountered by hospitals during the 1971 San Fernando quake:

Treat and Release		Admitted as in-Patients	
Fractures or related	18%	Fractures	26%
Cardiac	6%	Cardiac	19%
Emotional Reaction	9%	Psychiatric	12%
Lacerations	44%	Head Injuries	12%
Contusions	8%	Burns	7%
Remainder	15%	Remainder	24%

Although it is possible to argue the differences in the character of the area producing casualties in the San Fernando quake and those likely to do so in the event of greater quakes affecting the San Francisco health care system, we found no basis, not based on simple intuition, for changing

the above distribution. Nor did we presume to relate overall injury estimates to the type of physician and allied health professions which any distribution of injuries would be likely to produce.

A sampling of the intuitive judgments of interview respondents following a great (8.3) quake follows:

1. In either a daytime or a nighttime quake a relatively greater proportion of less seriously injured San Franciscans would report to hospitals rather than seeking their own physicians. This implies a larger relative number of treat-and-release cases, thus complicating crowd control and transportation problems around hospitals.

2. Medical personnel well qualified in the vital triage function are in short supply and poorly distributed. Those skills are presently concentrated among persons most likely to be needed in the treatment phases of casualty care. Enlargement of the cadres able to execute the triage function should be a major training objective.

3. San Francisco is thought to contain a relatively greater number of persons subject to emotional instability than was the case in San Fernando. Even were this not the case, the mental health component of the emergency response plan appears to be underemphasized. However, psychiatrists in private practice may be less experienced in handling the kinds of psychological crises likely to arise in the quake's immediate aftermath than are psychiatrists and non-physician workers in the city's counseling and crisis centers. Also, these kinds of crisis behavior are observed and responded to daily by emergency room personnel and many such personnel are thought to be quite skilled in recognizing and managing serious situations. The difficulty lies in a possible diversion of needed surgical and allied emergency personnel from treatment of the physically injured. Identification of others similarly skilled, and consideration

of their deployment, would be helpful in mitigating this problem.

All parts of the mental health community will of course have major roles to play after the situation has begin to stabilize and emotionally distressed persons can be seen in somewhat more controlled therapeutic settings. This was the case in San Fernando, but is not an explicit part of existing disaster response plans for San Francisco.

4. The effects of the Medical Society protocol which calls for member physicians to report to the nearest hospital, not the one of the principal practice, provides a potentially valuable organizing mechanism. Physicians operating under the protocol are to render assistance, if possible, and otherwise to await radioed instructions. Yet it is unclear how this protocol interacts with the provisions of the disaster plans of individual hospitals. Also unclear are:

(a) The extent to which member physicians are conscious of the protocol's terms

(b) The procedures applicable to the some 2100 physicians (53% of the total) who are not members of the Medical Society

(c) How quickly public radio and television broadcasting will be restored and instructions desiminated after a great quake.

5. There is general concensus that the initial phases of casualty care will be a holding action until the overall disaster response organization becomes effective and adequate communications are established within the city and with potential sources of outside help. Most interview respondents visualized a period of extremely stressful conditions burdened by inadequate assessment of damage and casualties and incomplete implementation of plans for lines of authority and resource allocation. Estimates of how long this period of relative confusion might last ranged from four to forty-eight

hours after the actual quake phenomena had ceased. It is obvious that fatigue and work stress on casualty care personnel will be important problems and that provision for relieving, housing, and feeding such personnel who are exhausted must be developed.

d. Problems of Residential Dispersion of Medical Personnel

We were unable to obtain any data which applied to residential dispersion of medical personnel by speciality or professional level. Furthermore, the data we obtained from a two year old hand tabulated survey conducted by the Women's Auxilliary of the San Francisco Medical Society accounted for only 1860 of the approximately 4000 physicians practicing within the city. This distribution by county appears below:

Residence by County	Number	Percent
San Francisco	1100	59.1
Marin	350	18.8
San Mateo	180	9.7
Alameda	170	9.1
Contra Costa	60	3.2

We would caution against applying these percentages to the approximately 2100 M.D.'s who are not members of the Medical Society. This latter group contains residents and interns of unknown number perhaps more likely to live in the city. Our study uncovered no "guestimates" of the non-members residing outside the city. The Medical Society Disaster Protocol directs member physicians outside the city to

(a) Remain where they are until radio directions are received if they are in an undamaged area;

(b) If they are in a damaged area, report to the hospital nearest their location when the quake occurs. (Implicitly they are to

offer assistance and to await instructions presumably coordinated through a regional disaster net.)

We were assured that specific (but unpublicized) assembly points are being or have been designated whence physicians will be transported by the most efficient functioning means (e.g., water transport, helicopter, or emergency land transport passing through undamaged or partially cleared land routes). It is also presumed that water transport would be provided by the navy or coast guard mobilized under federal disaster assistance mechanisms. The problem of debarking and dispersing personnel thus transported upon arrival in the city are discussed under the "Transportation" heading of this part of the report. Since this phase of the response effort will occur some hours after the disaster has struck, city physicians arriving from outside the city may be supplemented by military and other physicians made available, coming from areas largely or completely unaffected by the disaster. Allocation of priority for emergency physician transportation may be simplified by the likelihood that the Bay Bridge appears to the writers of this report to be less likely to be out of operation for so long a period as projected by NOAA and Blume. Water and air transport could then be concentrated on Marin and San Mateo counties.

e. Concluding Comments

There seem to be two other as yet unresolved problems in the area of casualty care personnel:

1. Support personnel (nurses, technicians, etc.) are critical to both the immediate and continuing response to a major disaster. Casualty losses among these groups are projected to be very high in an 8.3 quake. Yet provision for their identification, assembly, and assignment is generally lacking or at best sketchy in existing plans. We were, for example,

unable to locate any data on the residential distribution of R.N.'s nor did we find any evidence that nursing organizations had independently worked on disaster procedures. Of course the legal relationship between nurses and hospitals is quite different from that between doctors and hospitals. However, some of the same considerations dealt with in the Medical Society Protocol would seem to apply. For example, physicians are instructed not to travel across the city in order not to "add to congestion." Nurses who are employees of particular hospitals plus others volunteering for emergency service are apparently without consistent guidance in this respect. A possibly useful approach would be to direct nurses unable to walk to a hospital where they are regularly employed, to proceed to the nearest multi-purpose staging area, and to check in with the Red Cross there. The latter organization has performed well in other disasters with respect to the tasks of assembling nurses, checking credentials and transporting them to locations where they are needed. Interview respondents were not unanimous in support of suggestions that this problem's issues be left to the Red Cross, and the Red Cross was unable to make any firm commitments concerning the numbers of nurses that could be provided under the terms of the National Disaster Protocol between the A.H.A. and the Red Cross. Clearly other sources of emergency para-medical support should be sought along with the planning participation of other voluntary organizations (e.g., Emergency Department Nursing Association).

2. Physicians, allied hospital professions and patients are governed by a complex array of potentially conflicting regulations and guidelines including:

(a) Medical by-laws

(b) Hospital disaster plans (and other internal regulations)

(c) Hospital and physician malpractice considerations

(d) Medical Society protocols and ethical guidelines

(e) State, federal and local laws and regulations governing a variety of disaster related issues

Under ordinary conditions any given hospital develops formal and informal mechanisms for getting hospital work done in the face of these different sources of guidance and direction. A disaster situation quite literally demands suspension of many of the rigidities and unconstructive effects of conflict in guiding and control mechanisms, and depends on the flexible, creative judgment and interaction among key actors. Efficient short run response requires each hospital to develop plans which minimize the necessity to resolve conflict under crisis.

We were unable to complete this kind of review for any single hospital, but an example of our concern involved the authority of disaster response leadership over in-patient release relative to the authority of admitting physicians who may or may not be in or near the hospital. If provision for this problem appears in medical by laws (as it does in some cases), it ought also to be referenced in hospital disaster plans. If procedures on such problems differ significantly from hospital to hospital these differences ought to be known to the key actors expected to act at the city-wide level and opportunities for standardization should be explored.

5. Communications and Situation Assessment Capacity

A great earthquake will have profound effects on the communication system of San Francisco. Some of the more probable damaging consequences to general media types after an 8.3 San Andreas quake were studied in the 1972 NOAA research effort, and in the first subsection below we will report and comment upon these findings. Secondly, we focused our own study to discover the state of emergency communications specifically for health system disaster response operations after a large quake, and in the second subsection we will assess the capacity of current emergency networks to coordinate these operations to the levels of demand that should be anticipated. And thirdly, we will examine substantive issues concerning the health system's need to have reliable and ongoing information about the evolving situation of its disaster operations during the critical days immediately following such an event.

a. Overall media losses and disruptions

The communication services that NOAA analyzed were newspapers, major television and radio stations, special emergency radio networks, and the telephone system. An assortment of data was used to base predictions about the length of interruptions in each of these vital links to and between an anxious public and disaster response agencies. Typically, technical documents were analyzed and interviews conducted to describe the seismic safety of the facilities, equipment, and the distribution means for the service. Only in a few instances--most notably for hospitals--were new field inspections of facilities performed by engineers. The data thus provided to the NOAA team then was analyzed in relation to what the authors knew about the historical performance of current media technologies and

building structures experiencing different earthquake shocks.

The longest loss in communications was predicted for San Francisco's newspapers. After an 8.3 San Andreas quake, a mixture of electric power outages, misalignment or direct damage to printing equipment, and commuting difficulties for employees were attributed to cause delays of one week in all printed news publication.

A total loss in telephone usage within the city also was projected to follow an 8.3 quake.

(1) An estimated 50% of the telephone service for San Francisco, San Mateo, Santa Clara, and Marin counties was predicted to be out for "an indefinite period" due to equipment damage, particularly to underground cables.

(2) The remaining 50% of normal capacity in these counties was asserted to be "useless for telephoning in emergency situations" because these lines would be terribly overloaded by a "fantastic" number of attempted calls.

Given a 7.0 quake, NOAA forecast that 30% of San Francisco's telephones similarly would be out indefinitely because of damaged equipment, and the surviving portions of the system would be overloaded or unreliably accessible for many days because of the volume of calls this scale event also would generate.

The development of pre-assigned line limit controls by the Pacific Telephone Company and the city's Department of Electricity, however, has led officials in both organizations to suggest to us that an important restricted use of telephones may become possible 8 to 10 hours after either sized tremor. The implementation of these controls would allow persons and institutions who are pre-designated as essential emergency actors

to have relatively normal service within the surviving parts of the telephone system. Other phone users could receive calls but they would be prevented from dialing into the system and causing a massive overload that eliminated service ubiquitously. While we have not had time to independently survey the probable distribution of this restricted access emergency phone system, we have been assured by a representative of Pacific Telephone that all hospitals and the Department of Public Health's communications center currently are included. Furthermore, as the occupants of key disaster roles change over the years, and as new casualty care or resource coordination sites are planned, such alterations and additions reputedly can be incorporated quickly into this emergency phone network.

An 8.3 San Andreas disaster would disrupt all major radio and television broadcasting for 24 hours in both San Francisco and San Mateo according to NOAA. This estimate was based on an expectation of general electric power losses, some breaks in transmission lines, and other problems with broadcasting facilities and equipment. After 24 hours, approximately 50% of the radio and T.V. stations of the whole Bay Area were posited to return to the air. Although NOAA's authors offered no specific estimate of the percent of San Francisco and San Mateo radio and T.V. communications that would be restored during this second day, we presume that a number of these channels were implicitly included because the radio and T.V. stations in San Francisco county alone comprised about 50% of the Bay Area's total at the time their report was prepared. No estimates were made about the major radio and television networks' losses due to a 7.0 earthquake.

Special emergency radios for police, fire, health, the San Francisco Office of Emergency Services, and other disaster response agencies were

not field inspected or individually assessed in the NOAA study. They simply were identified as likely to share the same kinds of problems as those cited above to disrupt public radio and television. NOAA noted one difference, however. The presence of mobile radio communication equipment at the disposal of these emergency response agencies was suggested to create better opportunities for establishing radio coordination during the first 24 hours after a big quake, if base stations became inoperative, than was possible for the fixed public broadcasting system.

Our review of San Francisco's disaster response plans has revealed other differences. First, several emergency radio systems in the city have, or soon will have, auxillary electric generators that will allow them to continue operating immediately after a large quake unless these supplemental power sources or their radio sets and lines also are damaged. And second, police, fire, and within a year public health will have microwave links that give a backup connection to their Twin Peaks' transmitters so that destruction of ground transmission lines will not interrupt these three radio networks.

In summary, the findings of the NOAA study imply a very bleak situation with respect to communications access for the general public after a major quake along the San Andreas fault. For the first 24 hours after an 8.3 shock, the public probably will not be in position to transmit or receive any messages through the normal mass media channels of the telephone, newspapers, radio and television. Only special emergency radio and telephone connections might remain in operation, and those surviving links will connect an indeterminate number of employees and volunteers who are already in touch when the disaster strikes or who find the means to travel to pre-

designated and ad hoc sites that are part of an emergency network.

NOAA's Bay Area scope and its concern with predicting geologically related building damage and human casualty did not produce an analysis of the likelihood that particular parts of the disaster response structure would be capable of internal and external communications to fulfill their responsibilities. Our intention below is to stimulate this kind of detailed consideration for San Francisco's health system.

b. Emergency communications for the health system

The present framework for coordination of health and medical disaster operations in San Francisco relies heavily on specialized telephone and radio networks. The configuration of actors that are linked by each of these two systems is different and we will describe them individually.

(1) Radio coordination

Direct radio contact among all the essential local providers of resources and services for casualty care that are expected to communicate after a great earthquake would be initially unfeasible. First, many of the largest medical suppliers in the city and some of San Francisco's officially designated casualty care centers normally do not operate any radio equipment on their premises. The following is a list of some of these providers who are assumed in the city's disaster response structure to have crucial supply roles after a big quake and who currently lack emergency radios.

Casualty care sites:

Each of the Department of Public Health's five District Health Centers

Metropolitan Insurance Building

The Appraisers Building

Balboa High

Wholesale medical suppliers:

All of San Francisco's major drug and surgical supply companies and two of three blood banks in the city

Secondly, within the much larger group of health and medical disaster response units which do have radio equipment, there are several subsystems utilizing unique frequencies that stratify the potential radio system into either indirectly overlapping or normally isolated components. The largest subsystem (155.340) significantly connects all the major hospitals in the city, the largest blood bank, the Office of Emergency Services' mobile communications van, and--sometime during the 1975-76 fiscal year--the central communications center of the Public Health Department's Emergency Medical Services (EMS). A second subsystem (155.220) extends from the EMS communications control point in the Civic Center to the department's 14 ambulances, its four emergency aid stations, the Emergency Services van, and six major hospitals. Also within a year, this subsystem will be protected by a microwave link between the above EMS communications center and its 155.220 base station on Twin Peaks.

A third subsystem (30.66) functions between the Municipal Railway's approximately 500 diesel-powered buses that are to be available for conversion into casualty and mass transport vehicles in the event of large scale disasters and Muni's routine Presidio Ave. dispatch center and a backup remote control station on Forest Hill. Both of these radio control centers probably will remain dependent on ground lines to the 30.66 transmitter on Twin Peaks for the near future. The fourth, fifth, sixth, and seventh subsystems are San Francisco's private ambulance services (155.160, 155.280, 47.66, and 38.50), which are not linked directly by radio to each other, the EMS's current dispatching frequencies, or the

Muni. However, one of these companies does operate on a frequency that two major hospitals can utilize as a connection outside the 155.340 Hospital Disaster Net.

At the present time, the integration of these radio subsystems after a major quake only can arise indirectly, by messages being analyzed and relayed at one or more points where such subsystems meet. In the facilities description contained in the Emergency Communications Annex of San Francisco's Disaster Operations Plan, there exists no single convergence point in the city which even indirectly connects all the health related emergency networks listed above and has the capacity to link mobile units that might be assigned to the aforementioned casualty care and critical resource sites currently lacking any radio contact. The Office of Emergency Services' longstanding proposal to construct a general Emergency Operations Center near the Twin Peaks Central Radio Station could provide the basis for this comprehensive integration. So could additional allocations of fixed or mobile radio equipment that was configured around either the communications center for the EMS at 50 Ivy Street or Central Radio atop Twin Peaks. While we do not presume that a single convergence point is absolutely necessary for effective indirect radio communication pertaining to all aspects of health disaster operations and decision-making, the present lack of centralization in the health emergency radio system is a a contributing factor to several problems needing resolution.

(a) The casualty transport sector is vulnerable to a big quake because Muni's normal dispatching of buses depends on a land line to Twin Peaks for radio broadcasting and outside power from P G & E to energize equipment, and because there presently are insufficient radio interconnections between

the private ambulance services and the other dispatchers of casualty transport vehicles.

If the Muni's ground line for 30.66 is disrupted or the power for its communications center is lost, a dispatcher probably could be moved rather quickly to the Twin Peaks base station transmitter/receiver to restore radio contact with buses in a matter of hours. However, wherever this dispatching ultimately is done, a single operator attempting to coordinate up to 500 buses on one frequency would face great difficulties in monitoring and controlling their movements. The 30.66 transport link would be overwhelmed by air traffic unless extraordinarily simple protocols were predesigned for these purposes and conditions. For example, radio equipped buses might receive broadcast messages diverting them to the nearest Multi-purpose Staging Area (MSA), contingent on their route number, location, and fuel supply at the time of the quake. (Note: Some Muni vehicles on the administrative frequencies would also have to move to MSA's.)

Clearly, microwave protection for Muni's routine dispatch center would be a valuable investment for internal coordination and decision-making flexibility. Establishing a 30.66 capacity in the Emergency Services' mobile communications van also would be useful for on-the-scene or EOC associated coordination with other radio systems in the city, including the health system's 155.220 and 155.340 frequencies.

The lack of interconnectedness between the private ambulance companies and the Muni and public sector ambulances is being addressed in part by a Public Health Department plan to develop advanced telemetry/voice communications throughout emergency medical services in the city. An allocation has already been made to have this equipment installed during

the 1975-1976 fiscal year in the department's EMS ambulances and to partially defray such costs and stimulate participation in the private sector. If all private ambulance services decide to purchase any of several telemetry/voice equipment alternatives, there will then be eight shared radio frequencies on which these parties, the EMS, and participating hospitals could become directly linked during any disaster response operation.

However, several uncertainties remain with respect to the probability that radio communications for casualty transport could be integrated after a big quake. First, the present financial insecurity of private hospitals and ambulance companies decreases the likelihood that all ambulances in the city will become equipped with the new telemetry/voice capacity in the immediate future. Second, all nine Bay Area counties share the same eight telemetry frequencies; although planning has begun in order to automatically, or semi-automatically, allocate these channels according to the flow of revealed demands, an 8.3 earthquake and perhaps any shock of 7.0 and above would severely strain medical resource coordination in most Bay Area counties and this could overload the entire set of frequencies.

Third, even with eventual private and public ambulance coordination by radio, the Muni's much larger capacity for casualty transport remains tenuously linked to these other subsystems. Muni's indirect connection to the others is limited to am administrative frequency (31.140) that stems from its normal dispatch center to 60 mobile inspection units and the Central Radio Station on Twin Peaks, where the EMS is connected by a Local Government Net (158.760) that is shared with the Sheriff's Department, Department of Electricity, Recreation and Parks, and Police. If the electric power fails at Muni's Presidio Avenue dispatching center or the 31.140 land line to Central Radio is disrupted, this indirect radio link between Muni buses

and the ambulance sector will be broken.

Therefore, health and medical disaster officials may have to rely on configurations of mobile radio units that can be made available to interconnect the public sector ambulances, Muni buses, and the private ambulances after a great quake. An inexpensive option that might be worth exploring would be to plan for radio coordinating Muni's 60 mobile units that are on 31.140 from the Central Radio Station on Twin Peaks to all ambulance dispatch centers and Multiple Staging Areas throughout the city. Information about the entire ambulance sector then could be radioed to Central Radio, which is the city's official Primary Communications Center, and Muni's 31.140 linked mobile units could physically lead buses to and from staging areas along emergency access routes to and from hospitals and other casualty care centers.

(b) If disaster response planners are reluctant to assume the risks of telephone damage which may disconnect lines to official casualty care centers and major medical suppliers in the city, the second radio coordination problem needing resolution is how to extend emergency radio communications to bridge those voids we specifically listed on pages 46 and 47. Some obvious alternatives include making additional long term investments in fixed radios, preplanning allocations of existing mobile equipment, or dropping the currently assumed importance of those service and resource providers affected by the voids. The latter two options probably would cost only the staff time necessary to make them feasible. Generally, however, we were unable to assess the feasibility of each of these specific alternatives within the time frame of our study. We believe that they should be closely examined in the near future.

(c) A third radio coordination need is for San Francisco to develop a program of exacting simulation tests to evaluate evolving operational capabilities within and among each of the casualty care radio subsystems that we have been discussing. The level of demand for communicating on any of these coordination frequencies after a large San Andreas quake is likely to be beyond anybody's prior experiences. In a few cases (for instance, the Hospital Disaster Net and Muni's administrative frequency) key linkages that are not ordinarily used under intense emergency conditions may face continuous overload risks for 24 hours or more. Furthermore, the current system of emergency radio communications related to casualty care is complicated; until further investments are made to reduce this complexity, system integration may necessitate a high degree of entrepreneurial skill to organize the several indirect convergence points that may be required and to utilize mobile units to fill in normal and unexpected gaps. All of these factors, plus usual discrepancies between any system's design and its implementation, invoke this need for realistically difficult coordination drills that surpass the reputedly simpler kinds of testing currently employed.

Several interview respondents suggested radio drills should be centrally initiated and monitored in order to push existing coordination procedures to their limits and explore variously used methods for improving performance in stressful and demanding situations. A particular example of the need for this approach was cited by another informant whom we consider "authoritative", who wished to remain anonymous. A census of occupied and available beds in the city is attempted at the same time each day on the Hospital Disaster Net's 155.340 frequency by a PBX operator in

one of the city's private hospitals. Despite the routine nature of this inventorying, an estimated everage of 75% of the major hospitals in San Francisco reportedly do not answer the operator's call each day. As this crucial disaster frequency is not used presently for any other purpose, the ability of hospital radio operators to efficiently and cooperatively share this single connection during post-earthquake demand conditions will be very uncertain unless stronger incentives are brought to bear to reality-test the network.

Of course, centralization of testing strategies may not be necessary or efficient for evaluating every radio subsystem that would relate to casualty care after a major disaster. Detailed coordination tasks already involving emergency conditions are initiated and monitored daily by ambulance dispatchers and their supervisors, for example. The general case for ongoing test development and follow-up training being a high priority responsibility of central level health and medical disaster leaders, or their direct designees, appears to us to fit most practically the following three kinds of situations:

(1) when the overall health emergency radio system is to be examined,

(2) when unusual radio interconnections are to be tested, or

(3) when a radio subsystem not utilized often for health related communications is to be drilled for its capacity to do so.

The reason we think radio testing in these situations would best be centralized is that all of them presently involve inter-departmental or private-public sector cooperation, and therefore, executive action from one or more section heads of San Francisco's Medical and Health Disaster Service probably is necessary in order to insure adequate test development and implementation.

We have not surveyed the state of the art in radio simulation testing in the course of this study. However, our analysis of the coordination required of emergency radio networks for disaster casualty care operations educes two substantive suggestions for overall drills. One, a realistic earthquake simulation test of the present radio system should include the locating and dispatching of mobile coordinating units from selected indirect convergence points in order to bridge voids in radio contact "discovered" to emerge due to normal gaps in equipment, earthquake-caused damage to fixed radios in otherwise usable facilities, power outages, and line disconnections. And secondly, a variety of situation assessment procedures pertaining to changing conditions affecting the casualty care centers, on-the-scene coordinators, and the casualty transport sector should be tested for feasibility under different threshholds of demand. We will examine some of the specific kinds of situational information needed by health and medical disaster leaders in a later section.

(2) Telephone coordination

If the general losses in telephone usage from equipment damage predicted by the NOAA study are normally distributed with respect to the various casualty care related institutions that we assessed for radio coordination, an 8.3 San Andreas quake will cut off 50% of their phones for an indefinite period and a 7.0 tremor will disconnect 30% of them. A strong implication of this estimate is that the telephone should not be relied on as a general coordinating mechanism for casualty care operations.

A partially surviving phone system, however, might serve quite important limited communication functions after a big quake. Assuming that Pacific Telephone's line limit controls worked perfectly and all

necessary health and medical related providers actually were in the phone company's essential emergency actor subsystem, then 8 to 10 hours after the disaster struck these controls would be functioning and a survey of the emergency phone networks for casualty care operations could be attempted from the Emergency Operations Center, Primary Communications Center, or individual subsystem control points. If this survey revealed that any key provider without radio contacts was interconnected by telephone to an operational emergency communications center, then that phone link could serve either as a substitute for a mobile radio assignment or as backup capacity to increase the flow of messages to and from the provider.

Thus, one function of the emergency phone system could be to allow central decision-makers to generate some flexibility in rationing mobile radio units, if the emergency telephone and radio systems were coordinated in patchwork fashion 8 or more hours after the Medical and Health Disaster Services began operating. An example of this trade-off option would be in the creation of a coordinating link between EMS central communications and a private ambulance dispatch center. Alternatively, in some cases decisions probably would be reached to preserve as much two-way communication as possible; for instance, at hospitals.

A second limited function for the telephone could be as a tool for organizing ad hoc assignments and assembly points for casualty care personnel. If all essential personnel have been contacted ahead of the disaster and know in advance what duties they will perform and how they will be transported to these assignments after a great quake, then the emergency phone system only need be engaged to try to alter such plans to adjust to unexpected events. However, if radio or telephone reports from casualty care resource providers depict a picture of missing personnel that suggests information losses

for particular kinds of essential staff members, then central Medical and Health officials might decide to initiate a phone canvassing effort to discover what obstacles are preventing these employees from getting to their disaster posts. After such information has been gathered and the location of said employees has been centrally assessed, the telephone could be utilized, again, to transmit new instructions for assembling and transporting any stranded employees who are vitally needed.

Third, the telephone undoubtedly would be employed by hospitals and other casualty care centers, on a decentralized basis initially, to obtain additional supplies and equipment from all usual key providers. However, because an earthquake in San Francisco is quite likely to differentially damage supply houses in various parts of the city, this event may result in relatively abundant resupply situations for some casualty care centers, while others face awkward scarcities. Therefore, it may be necessary at some early point after such a disaster for central Medical and Health officials to establish communication control and physical security over the allocation of critically needed supplies at the city's largest wholesale supply locations (for particular examples, see our section 7, Medical Supplies and Equipment).

If such a decision were made, and there was a supporting and efficient central distribution system to implement it, at least one telephone at each of these large suppliers could be continuously engaged by a phone at the Emergency Operations Center, or another designated communications center, for the purpose of centralizing supply decisions. Casualty care centers could be required at the time that allocation controls went into effect to telephone or radio their supply needs to this central communications point,

according to a planned protocol. We do not recommend this degree of centralization, however, unless hospitals and other preassigned casualty care centers agree in advance that a guarantee of fairness necessitates control over large stocks of medical and health related supplies in the city, leaving neighborhood pharmacies and other small suppliers to be telephoned individually by local casualty care operators.

Other uses of surviving phone connections probably will need to be invented by emergency personnel as evolving conditions are evaluated and communication responses organized. Additional possibilities can be derived from our discussion below of situation assessment capacity. Nonetheless, such planning of telephone coordination roles for emergency operations after a large quake must be realistically limited to functions which do not assume city-wide phone linkages. Depending on the actual distribution of disconnections, it may happen that the telephone will turn out to be a surprisingly available resource for health and medical coordination; but in our opinion, this contingency would best not be depended on where casualty care operations are to be linked. For these services, we suggest that the telephone be planned as a secondary communication system to back-up special radio networks, expand total message volume, and meet unanticipated needs after post-quake telephone supply becomes known.

c. Situation assessment capacity

A crucial and difficult challenge facing the emergency communications system for San Francisco immediately after a major earthquake is to begin supplying key actors with essential and reliable data needed to analyze the impacts of the disaster on the city. In the first stage, according to the current Earthquake Response Plan, the emphasis in this reconnaissance

effort will be on the range of physical damage already befallen or threatening to endanger lives and general building structures, predesignated vital facilities (such as dams and hospitals), streets and freeways, and utilities. Somewhat later within the first 24 hour period, as emergency services attempt to fully organize to meet their obligations, the kind of data that is expected to flow and be evaluated will more extensively concern the operational conditions and resources affecting levels of service to survivors. To a substantial extent, data development for these two kinds of situation assessment processes will differ and we have decided to analyze them separately. However, one should expect that in real time both data flows and analytical efforts will overlap, and at times they may be in competition for the decisional resources available at any Emergency Operations Center.

(1) Assessing physical damage

The responsibility for initiating and coordinating data origination about the extent of post-quake damage rests mainly with the city's Office of Emergency Services. If the tremor is "severe" (broadly defined by the Earthquake Response Plan as "felt with high probability of death, injury and extensive damage"), first the Mayor will be asked to declare a Local Emergency and then the OES Director will organize a reconnaissance effort which includes the following principal activities:

(a) The Sheriff's Air Squadron will be directed to undertake aerial surveys to locate the areas experiencing heaviest damage, fires, and any flooding; the state or bridges and their approaches, the condition of freeways; any collapsed overpasses, etc. This squadron includes some STOL craft (short take-off and landing capacity) so that freeways and open spaces will be used for landing if necessary and if safeguarded by State Highway

Patrol or San Francisco Police. Since aerial photography is not a part of their current capabilities, however, these surveys will not generate detailed information about the passability of streets for casualty care transport and other essential ground vehicles.

Additional airborne means for obtaining precise data on street access throughout the city have been recently explored, but at the time this report was prepared, they were stalled by technical constraints. The most elegant solution to this problem of rapid yet comprehensive information about street passability would be a single "snapshot" electronically transmitted from a satellite. However, Bay Area and State OES efforts to implement such a strategy have failed to date because the National Aeronautics and Space Agency (NASA) has been the only satellite administrator reputedly willing to consider this use and their satellite equipment has been described to us as presently incapable of producing the very high resolution images needed. A second-best solution that still is being explored would involve several "snapshots" of the city taken from U-2 aircraft. The technical problem with this strategy has been the large amount of time--at least 24 hours--estimated to complete reconnaissance flights and produce photographs in a convenient form for analysis by disaster response administrators.

(b) Emergency radio managers in various San Francisco departments and official disaster volunteer organizations will be instructed to poll geographically representative facilities and dispatch vehicles in order to ascertain general damage in their vicinity and their own ability to function. The responsibilities of the organizations that will be surveyed, as charted by the Earthquake Response Plan, imply the following types of data will be among those initially sought:

- the location of blocked streets
- boundaries of major fires
- hazardous situations requiring immediate rescue
- damage to preassigned casualty and mass care facilities
- water, power, and gas interruptions
- loss of communication capacities and other vital equipment
- estimated overall damage by neighborhood
- initial impacts on the mental and material welfare of the population in each of the ten disaster response districts.

We have been unable to discover the likelihood that most of the above data will be reported in a form that will aid in health and medical decision-making, however, because specific radio data collection and assessment designs have not been proposed in the overall Earthquake Response Plan and we did not have time or authority to probe for the detailed assessment needs of leaders in any sectors beyond those directly related to emergency medical care.

(c) Hospitals, dams, bridges, government headquarters, mass care centers, and other "vital facilities" will be scheduled to receive damage inspections from outside experts as well as assessments from their own maintenance staffs. Although no advanced agreements with the city's largest structural engineering firms to supply these needed experts have as yet been completed, the Building Inspection Department intends to develop such contingency arrangements in the near future to supplement their normal inspection capacities. Transmission of reports on the nature of damage these facilities sustain and their surviving capabilities will depend in some instances on the dispatch of mobile radio units that accompany field investigators. For example, this is generally true for mass care centers in buildings, which the Red Cross will link by dispatching mobile radios

vehicles and mass care centers expected to be created in large open spaces, which the Recreation and Parks Department plans to connect by its mobile units on the Local Government net.

In order to organize and evaluate the many streams of specialized data that these three initial reconnaissance efforts will generate, and allow even rough checks on the reliability of the geographical and functional composite of the city that different sources depict, two requirements appear to us to be critical. First, a convergence point is needed to bring all of this data into one place within the purview of central information processors and decision-makers. Specifically, the Mayor, Emergency Services Director, City Planning staff (which is responsible for managing central informational needs and dessiminating situation intelligence) and the Chiefs of Primary Response Services truly need to be in close physical proximity to each other in order to scrutinize and discuss the relevant damage and surviving capacity estimates the data system delivers. Otherwise, they may separately internalize different assumptions about the state of the city in their decisions.

And secondly, fixed or portable data processing, storage, and retrieval devices need to be available at this point where the data converges in order to create useable records, keep track of simple statistical histories--various supply inventories, for example--and perform relatively easy but essential manipulations of variables, such as projecting trends of resource utilization relative to estimated capacity changes.

Unfortunately, at the present time, both of these needs have not been met in San Francisco. A proposal to build a new Emergency Operations Center (EOC) adjacent to the city's most comprehensive radio station, on Twin Peaks, continues to lack political support despite the fact that there is no

EOC available in the city which currently can be an adequate meeting place for radio systems and key disaster officials, along with vital support personnel. Furthermore, no data processing equipment possessing significant storage capacity has been allocated either to the Office of Emergency Services or the City Planning Department, although the latter has a reasonable prospect of obtaining a transportable micro-computer in the near future that would begin filling this gap in computational capacity.

The general state of damage assessment described above also contains certain implications for the health and medical subsystem. Standardized protocols for describing damage and surviving capacity in casualty care components need to be initiated by the members of this sector in order to ensure that a practical method exists for coordinating multiple radio frequencies within and among the sectors. Some basic elements of these standard forms might include: an index of present capacity (e.g., available beds in treatment centers), how much extraordinary capacity can be created (e.g., from safely discharging certain categories of patients and setting up cots), and any emergent supply bottlenecks (e.g., blankets, suture sets, and blood).

Finally, the present lack of citywide computing equipment assigned generally for situation assessment processes suggests to us that the health and medical subsystem ought not depend on external sources of data processing capacity. Hardware and software to enable analyses specifically for health and medical damage assessment, and operations assessment, needs to be incrementally purchased or otherwise secured as soon as the dimensions of these information needs are decided, standard reporting protocols are adopted, and cost studies are made to determine the feasibility of various portable devices.

(2) Operations assessment

Our findings with respect to citywide damage assessment capability apply equally to any comprehensive attempt to monitor the demands, activities, and ongoing resource situations faced by San Francisco's disaster response services. Without (a) an adequate City Emergency Operations Center, (b) general protocols for reporting essential data in a form which ensures that the vital informational needs of the casualty care sector will be met, and (c) without useful data processing equipment assigned to become available at any designated EOC, the health and medical subsystem has a great responsibility to develop its own operations assessment program. However, the focus in developing such a program can be tighter than with damage assessment because fewer actors outside the health system need be involved in reporting and analytical processes.

Many of our respondents expressed similar views of the major types of operations data would be most generally needed by casualty care decision-makers. In the following section, we will briefly outline some of these dimensions that could serve as a common basis for evaluating operations. The communication system assumed is primarily radio coordination, as described in previous sections.

(a) On-the-scene information

Field coordinators for the triage and transportation of casualties to treatment centers or morgues need to know about the changing availability of hospitals for agreed upon classes of patients. In turn, they must provide information about the need for added help and supplies, the numbers, types, and tentative hospital assignments of casualties.

Optimally, scene triage might include several classes of injury sorting, with I.D. tags attached to casualties to indicate type of injury

and mode of transport recommended. A refined taxonomy for injury sorting, which was reported in The American Hospital Association's Readings in Disaster Preparedness for Hospitals, 1973, p. 19, included five casualty classes:

Class I: Victims with minor injuries which can wait indefinitely for treatment, or require no treatment.

Class II: Victims with injuries demanding definitive treatment in a hospital (or other casualty care center), but in which treatment can be delayed.

Class III: Victims with injuries which are life endangering and demand immediate transportation to a medical facility.

Class IV: Victims with injuries so severe that survival could not be expected under the most ideal conditions.

Class V: Victims fatally injured.

Transportation organizers at points where assignments of casualties are being arranged will need to know the access routes to each treatment center, traffic controls along these routes, crowd conditions adjacent to treatment centers, the number and types of vehicles being assigned to them at various times, and the fuel supply situation.

(b) Casualty care centers

Information to and from treatment centers basically will be needed to depict the altering supply and demand capabilities of these centers and the security of their operations from external crowd conditions. Site administrators will need to know the kinds and number of casualties being sent to them for treatment and the availability of external resources critically needed to meet these demands, including:

- essential medical supplies and equipment
- water supply and sewage disposal, if ground connections are broken
- staff additions to increase capacity or relieve exhausted staff members at various times
- police support for crowd control at access points to the facility

(c) Central level information

Decision-makers at one or more central control points will need to monitor the overall conditions affecting casualty care subsystems, including on-the-scene activities, the evolving capacity of treatment centers, and the operation of transportation and communication linkages. In addition, the data they obtain about these operations, if processed into projections of critical bottlenecks, will provide the basis for requests of resources from other sectors of the city and from other counties, State and Federal sources.

Again, creating this assessment capacity requires, in our opinion, that (a) standard inventory and other reporting formats be preplanned by central level Health and Medical disaster leaders and members of each particular subsystem, and (b) that suitable data processing equipment be preassigned to control centers. At the present time, neither of these needs have been generally met. Finally, satisfying central informational needs during at least the first 8 hours after a major earthquake, when no phones are expected to be working, may require that radio connections be established by mobile units where no radio capacity normally exists--at the large medical supply houses and the casualty care facilities listed on pages 46 and 47.

6. Transportation for Casualty Care

a. Ambulances

At this writing, San Francisco has 61 ambulances of city, federal and private ownership. Making the most optimistic of assumptions about the conditions prevailing after a great quake, these vehicles could transport less than 3300 patients from injury sites to casualty care facilities during any 24 hour period.

Such assumptions would include:

(1) No quake-caused vehicle loss

(2) No breakdown during the disaster response period

(3) Abundant, accessible fuel supplies

(4) Full availability of ambulance crews

(5) Optimal communications and dispatching capabilities

(6) Minimal delays at casualty care facilities

(7) Congestion- and damage-free transportation arteries

Since it it probable that most of these assumptions are not valid, the city's ambulance force can play but a minor role in the movement of injured persons to and from casualty care facilities. In fact, the following planning assumptions should be applied in any major quake occurring over the next several years.

1. A minimum of 8-10 ambulances would be out of service due to collapse of storage structures or buildings adjacent to where vehicles are typically parked.

2. Mechanical failure due to ordinary wear and tear is not estimated to be a factor for the Public EMS ambulances for at least a week. We attempted no review of the mechanical reliability of other ambulances.

Using purely statistical approaches (e.g. the public EMS looses 1/7th of an ambulance per 24 hour period of operation) and making some allowance for more hazardous driving conditions, we believe that the city's entire stock of ambulances should be assumed to be subject to a "decay" of one ambulance per 24 hour period following a great quake.

3. All ambulances are gasoline driven and therefore dependent on underground fuel supplies which require electric pumps to get them into the vehicle tanks. Assuming that ambulance gas tanks are on the average half full, an average speed of 19-21 overall, and a maximum gasoline mileage of 6.5 mpg, the ambulances within the city can operate continuously for less than 6 hours following a general electrical failure. This factor alone would reduce by 75% the expected casualty-carrying capacity of the city's ambulances during the first 24 post-quake hours barring infusion of tank truck borne fuel from outside.

4. No private ambulance companies operating within the city have disaster plans which provide for assembly of off-duty personnel and coordination with public sector casualty care managers. The public EMS has distributed identification cards, but off-duty employees have widely dispersed residences; many outside of the city. Neither public nor private ambulance employees are understood to be included in plans for disaster transportation - as are physicians. Relief of crews on duty in the quake's immediate aftermath would require a tightly administered identification system for all ambulance personnel and provision for allowing them access to special transportation from suburbs into and within the city.

5. Ambulance radio communications will be adversely affected by general power failures but are unlikely to be completely disrupted (see Communications section). Optimum use of ambulances more completely

equipped with life support systems would depend on first stage triage having occurred prior to the ambulance's arrival and use of these vehicles primarily (if not exclusively) for transport of the most seriously injured. At present, triage capacity apart from aid stations and hospitals, is limited, so that ambulance technicians would have to consume some time transporting less seriously injured or in conducting "transport triage" on the scene.

6. Hospitals and other casualty care facilities will vary considerably in the efficiency with which they can diagnose and treat mass casualties. Even under ordinary conditions, emergency room entrances at hospitals other than San Francisco General are often constructed with modest expectations of ambulance arrival frequency. Although reportedly most hospital disaster plans envision establishment of a triage/treat-and-release area away from ambulance entrances, all the approaches to hospitals should be assumed to be congested by crowds of injured, their relatives or friends and others seeking shelter, aid, something to do, etc. In order to limit the delaying effects of this sort of congestion on delivery of seriously injured patients, limited police manpower for crowd control might be augmented by volunteers and hospitals might obtain and store barricades to help ambulances pass directly to the entrance. Assumptions by hospitals that ambulances are carrying most severely injured patients would have to be sustained by good faith efforts by ambulance dispatchers and technicians to make such assumptions valid.

7. San Francisco is geologically complex and the materials and underlying structures of its streets are highly variable. Following a

great quake, streets in areas denoted by Blume as subject to "A, B or C" shaking are subject to rupture and may contain quantities of rubble and broken glass impassible to trucks and ambulances. Subsidence and liquifaction potential in some of the same and other zones raise further questions of passibility. Collapse of overpass structures is also a problem. Additionally, autos, trucks and transit vehicles on the streets at the time of the quake may become disabled and be abandoned in spots where they create obstacles to the expeditious movement of emergency vehicles.

While large areas of the city have a potential for these sorts of damage, it is probable that few areas will be completely inaccessible given timely assessment of alternative, though probably circuitous routes. Persons with responsibility for allocating, dispatching and driving ambulances should acquaint themselves with areas subject to the greatest hazard and should devote intensive initial post-quake efforts to informing themselves as to the availability of alternative routes for passage and access to injury sites and casualty care facilities.

b. Alternatives to Ambulances

1. Walking

As a practical matter, most injured persons will begin the search for medical attention for themselves on foot. Those unable to walk may cause other less severely injured or uninjured to seek help - also afoot. A daytime quake would result in 300,000-500,000 persons in the streets as buildings in congested areas emptied. The problems created by such masses have been alluded to above. In the event of massive power failures or mechanical malfunction of elevators, stairwells of tall, densely populated

buildings will be rather hellish places even if individual buildings have well developed evacuation plans. Attempts to discourage people from leaving buildings after a major or great quake would seem to be unrealistic. Instead, volunteers or marshals equipped with portable battery-operated bull horns could be identified and trained to route masses to staging areas. Rescue of non-ambulatory injured left behind in damaged buildings can be organized as part of this process.

Persons evacuating buildings containing numbers of physicians' offices might be encouraged to carry out medical supplies for subsequent use in medical treatment. Conversely, larger amounts of supplies in pharmacies need protection from looting or random "acquisition" until official procedures for purchase and transport come into operation.*

2. Muni Buses

The largest potential source of mass transport is the fleet of some 500 (the figure is approximate because of current bus purchase and retirement plans) radio-equipped diesel buses. All of the larger buses have 120 or 125 gallon fuel tanks. For planning purposes, it should be assumed that these tanks would, at any one time, be half full (i.e.60 gallons). From the Muni's Deputy Chief for Operation and Engineering we obtained a rough estimate of 1800 gallons/hour used by these buses during rush hour conditions. Taking this estimate as a useful measure of consumption during disaster response use of the buses, this fuel source would keep the fleet in operation for about 16 hours. The Muni's fuel reserves of 40,000-60,000 gallons of diesel fuel may be tapped only through use of electric pumps. The Muni has no current plans to acquire auxiliary power generating equipment for use in the event of a prolonged power failure.

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* Depending on the hazards involved, critical drug supplies and equipment for treating trauma located in structures in eminent danger of collapse might be moved to street locations where they could be better protected.

The Muni has stored 1300 litters suitable for installation in buses and this would equip some 150 vehicles for transport of the injured. Muni has not carried out a continuing inspection of the litters and the paper blankets stored with them and cannot vouch for their condition. Responsibility for this inspection might usefully be made joint with the EMS in the Public Health Department and a program for replacing deteriorated units initiated as budgetary constraints allow.

Litter equipped buses will not be ideal for transporting persons so severely injured as to require intensive first aid or life support treatment during transit. Placing one or more casualty care personnel on board a bus may help discover and give first aid to medical problems (e.g. internal bleeding, shock) not apparent during pre-transportation triage. The Muni's radio system, if its present dependence on ground line connections is eliminated, could then arrange for a relayed message to a casualty care facility and permit re-routing of the bus to a facility in possession of higher medical technology if needed.

Both litter and non-litter equipped buses would be of critical value in moving "treat and release" and uninjured persons not assigned volunteer roles away from congested casualty care facilities.

Another potentially useful preparation would be the printing of large print signs to be placed in the front, rear and side windows of Muni buses to identify the purpose for which the vehicle was being used (Casualty Transport, Mass Care Transport, Evacuation).

3. Commuter buses (A/C, Golden Gate, Greyhound)

Of the three major bus lines storing vehicles in the city during daylight hours, only A/C is a plausible contributer to the casualty care

response. In other words, if the Bay Bridge is available for at least emergency shuttling, these buses could be used to bring medical supplies and personnel from the East Bay into the city. However, at least three problems raise questions about this possibility:

(a) the buses are stored in or on seismically risky structures;

(b) drivers do not remain in San Francisco during the hours the buses are stored;

(c) radio control of A/C's resources would have to come as a result of State coordination and may appear less attractive than the use of other vehicles if the bridge is limited to shuttle traffic for any appreciable period of time.

The Golden Gate Bridge Authority's buses are more likely to survive a quake undamaged. However, their use for evacuation or transport of medical personnel from Marin and Sonoma counties is not a good prospect given the unreliability of Golden Gate Bridge approaches and the presumed availability of water transport from those areas.

4. Aircraft (Helicopters/STOL)

As tools in the immediate casualty care response, these kinds of craft are highly attractive. They are unlikely to be abundantly available until a federal emergency is declared. Their use in transportating injured within the city to casualty care facilities appears to be anticipated generally. Certainly, landing places would exist on undamaged portions of freeways and open spaces such as the Marina Green, Crissey Field, etc. There have been no drills involving either type of aircraft. Particularly with respect to helicopter landings near hospitals, the absense to date of drills adds to the risks of plans based on the use of helicopters for casualty transport. STOL craft, however, represent a plausible approach to bringing in personnel and supplies from military bases and unaffected medical

facilities as far away as the Central Valley.

5. Water Transport

The Mayor's Office of Emergency Services has been assured by the Coast Guard that a substantial flotilla of well-equipped craft can be made available for transport of personnel and supplies as well as evacuation. The abundance of water routes between the Bay and inland ports makes this a highly reliable and important resource. The major problem is the shortage of landing spots (the eastern and parts of the northern waterfront are likely to be heavily damaged and largely inaccessible) from which personnel and supplies can be readily dispersed and to which evacuees can be transported. Again, small scale drills using actual water craft would seem essential before proceeding on the basis of this element of the disaster response plan. Furthermore, placing representatives of the Chiefs of Medical, Hospital Care, and Supplies (with radio contact to the EOC) at designated landing points would be a highly useful addition to the health care aspects of the overall plan.

6. Private and Commercial Vans, etc.

Interview respondents spoke of the considerable number of vehicles in the city which could carry recumbent passengers. Among the possibilities are bread trucks, step vans, and commercial delivery vans (1/4 - 3/4 ton). Trucks with separate cabs for drivers are less desirable. Organizing, identifying, and controlling these vehicles as well as compensating owners are problems for which we identified no solutions. Some of these vehicles are equipped with hydraulic lift gates--an invaluable tool in evacuating the some 10,000 San Francisco residents confined to wheelchairs and unable to enter buses. Some people in this last category would presumably be

injured and would require special casualty care procedures which have been incorporated in the training of drivers and attendants in Berkeley's police ambulance service but not, as yet, in the San Francisco EMT training program.

Secondly, virtually any large city contains a number of privately owned vans with removable seats whose services might be volunteered. Organizationally this potential resource ought to be channelled through the Red Cross and not be incorporated directly in any health department-developed planning assumptions or measures.

7. Motorcycles, etc.

Motorcycles are an excellent source of highly mobile reconnaissance capacity and are often able to pass through areas inaccessible to buses, cars, and ambulances. From a medical standpoint, they can be used to transport small quantities of critically needed medical supplies and individual medical personnel unable otherwise to get to assembly or duty points. Police motorcycles should be assumed to be fully engaged in other duties. None of San Francisco's 17 commercial messenger services have motorcycles. They do have radio equipped bicycles, some equipped with 400 lb. capacity carts. In those areas south of Market, subject to extensive street rupture and building collapse, these services might be initially very useful. They are not currently available on a 24-hour basis but our telephoned inquiries produced statements of willingness to make prior arrangements for rapid after-hours mobilization.

Privately owned motorcycles, of greater utility in hilly sections of the city, are difficult to mobilize. We were unable to make contact with the California State Motorcycle Association. We did contact a major

motorcycle retailer who volunteered to organize other retailers in a survey of San Francisco motorcycle owners to assess their capacity for assembly and emergency transport.

8. Land Connections to points Outside the City.

There is little that any of the key health care disaster response personnel can do to directly assess or respond to phenomena occurring outside the city which affect the movement of supplies and personnel. Nonetheless, it is important for each of the health care managers to understand the major planning assumptions about these linkages to the outside and, during the planning phases at least, to support or work for measures which lead to the most rapid re-opening of links with the highest capacity to bring the means of saving lives, reducing incidence of permanent disability, and restoration of the general conditions conducive to public health. Therefore, we have elected to briefly discuss each of the existing linkages in terms of their possible contribution towards accomplishing these goals.

(a) Links to the South.

San Mateo County is the residence of a significant number of commuting health care personnel. Of equal importance, Santa Clara County contains major hospital resources not easily contacted by water. Most importantly however, San Francisco is alarmingly short of heavy duty mobile construction equipment of vital use in restoring vehicle access to areas where large numbers of injured are likely to be found, and in clearing ways to casualty care facilities. While the amount of such equipment available from San Mateo County varies,* that area has been targeted as the principal source of non-military street clearing equipment.

*Construction contractors have powerful financial incentives to keep equipment in operation and thus to have it at work at sites remote from areas where it is stored when idle.

Unfortunately, highly unstable underlying materials and proximity to the San Andreas fault lead to projections that the City will have no land link to areas south of Candlestick Point on the Bay side and the slopes of the San Bruno Mountains to the west. The routes which offer some potential for relatively rapid restoration of access are those from El Camino Real/Mission Blvd eastward onto the slopes of the mountain. If the potential for heavy duty relief from the south can be quickly assessed, given high priority to getting an emergency route cleared could accelerate the restoration of access to and from congested areas. This course of action is, at best a shaky one and should be followed only if the time and scaler tradeoff between it and awaiting availability of military resources are favorable.

(b) Links to the East.

Although not a major source of health care personnel, the East Bay counties are the most important potential sources of supplies and offer the most capacity for evacuation of the injured and homeless. Obviously, the Bay Bridge and its approaches are the critical component of this alternative to relying wholly on water borne or air transport. Even a severely restricted Bay Bridge (e.g., one lane in each direction) has vastly greater hourly capacity for carrying people and goods than any imaginable flotilla and does not require any off-loading and transfer once the city has been reached.

Blume, NOAA, and the Toll Bridge Authority engineers with whom we consulted were in essential agreement that the Bay Bridge would survive an 8.3 quake. However, vehicles on the Bridge during the quake would be almost certain to go out of control and create a considerable amount of

wreckage, effectively preventing passage until a pathway having the equivalent capacity of two lanes could be cleared. If the wrecked vehicles can be pushed aside (i.e., not towed away) this clearance on the deck least in use at the time of the quake could be accomplished by CALTRANS maintenance equipment which is readily available.

Blume recognized the considerable reinforcement to elevated structures on the bridge's western approaches completed since the 1971 San Fernando Quake. That report correctly stated that these measures have never been tested in a large quake but agreed with CALTRANS that the reliability of these structures has been greatly increased since NOAA projected their collapse. The western off-ramps are constructed on the most stable rock close to the downtown area and are not expected to collapse from sub-structure failure.

The eastern approaches are much less reliable. NOAA and the engineers who developed the report remain emphatic in their insistence that the toll plaza area is subject to differential subsidence due to unstable underlying fill.

Toll Bridge engineers report that this area has, since its construction nearly 40 years ago, experienced considerable natural subsidence which has been compensated by filling with asphalt and gravel. Aside from the compaction which this process has caused, the pavement in the toll plaza is now as thick as 8 feet and while subject to some rupture and vertical displacement in heavy shaking, repair capabilities in the immediate area lead us to argue (with CALTRANS support) that emergency lane service on the bridge could be given within 3-5 hours after shaking ceased.

Our inquiries produced considerably less confidence concerning I-80,

SR17, and SR24 approaches to the toll plaza. Some of the elevated structures have been reinforced but others are anchored in material subject to heavy shaking in an 8.3 San Andreas quake. However, we find implausible the notion that all approach structures will fail, thus barring any access to the bridge from the east.

We would argue in conclusion that the Bridge should continue to be a factor in earthquake disaster response planning. The immensity of its capacity, its relatively high reliability, and the vastness of the resources to which it is connected render unwise, in our view, any blanket assumption that it will be unavailable to the City in meeting any such crisis.

(c) Links to the North.

Although opinions vary as to the structural reliability of the Golden Gate Bridge, it is definitely a less formidable structure than is the Bay Bridge. In fact, a modest controversy regarding its reliability in a great quake has continued since its construction. More importantly, its approaches and connecting routes are subject to considerable landslide hazard, particularly during the wet season. Furthermore, Marin County is a factor in San Francisco's quake disaster planning only insofar as it is the residence of the largest group of commuting physicians. Water borne access to Marin County is good and is needed primarily in the event that the disaster occurs at nighttime or on a weekend and the negative assumptions concerning the Golden Gate Bridge and its approaches prove largely correct.

9. Rail Transport.

Multi-purpose rail transport is available only to the south and links in this direction pass through zones which are shared with extremely unreliable highway routes. Thus the Southern Pacific's facilities are

unlikely to be of significant assistance for an indefinite period following an 8.3 quake on the San Andreas fault.

BART's transbay link was constructed to withstand vertical and horizontal displacement equivalent to that estimated to have occurred during the 1906 quake. The tube also has very substantial de-watering capacity installed. However, dependence on electric power and uncertainty concerning the stability of underground and elevated facilities on both sides of the bay led us not to inquire extensively as to BART's potential as a carrier of supplies and personnel. It's availability in the immediate aftermath of a quake is definately less likely than either the Bay Bridge or military operated water borne transport.

7. Medical Supplies and Equipment

The effects of a large quake on the equipment and materials that casualty care facilities would use or consume have been presumed to vary subject to:

(1) The damage which individual hospitals actually sustain;

(2) The category of supplies under consideration:

(a) pharmaceutical and surgical supplies

(b) blood

(c) equipment

(d) water and sewage systems

(e) energy

(f) food

(g) record keeping supplies and equipment;

(3) In the case of consumables, the number of days' supply routinely kept on hand;

(4) The relative proportion of liquid supplies stored in breakable containers, open shelving or closed shelving which is unsecured.

The following discussion deals with each of the major categories of supplies and equipment. For problems (3) and (4) we could not locate adequate data and will recommend inclusion of inquiries on such points in future studies.

a. Pharmaceutical and Surgical Supplies.

Without specifying the mathematics involved, the NOAA report projected combined losses of supplies and equipment based on data from the 1971 San Fernando quake and the 1969 Santa Rosa shock. This report also simply asserted that, "the San Francisco Bay Area will have a larger

proportional loss of specific supplies, particularly liquid type drugs stored in shelves in fragile containers." The actual estimates for losses were in terms of dollar loss and were as follows:

Magnitude 8.3	60-70%
Magnitude 7.0	20-30%

There seems little point in attempting to guess the breakdown intended between high cost, hard-to-replace medical equipment and relatively low cost, more readily supplied drugs and surgical supplies. Hospitals faced with overwhelming increases in demand for certain consummable drugs and supplies needed for quake casualties will quickly exhaust any conceivable amounts of these types of materials on hand and resupply from commercial sources will be necessary.

Interview respondents and the NOAA report expressed little concern as to the post quake presence of adequate supplies in the Bay Area. This is due to the relatively small projections for stock losses to pharmacies and wholesale suppliers. There was concern about the transport of supplies and their rational allocation among casualty care facilities.

In fact, with military assistance or the fortuitous survival of the Bay Bridge in a useable state, a flow of supplies from outside the city can be begun within a few hours of a great (8.3) quake. Drug needs in the event of a San Andreas quake measuring 7 or less could probably be met from sources in or near the city.

Remaining to be resolved under great quake assumptions are the following:

(1) the quality of mechanisms at individual casualty care facilities for accurately assessing needs and their ability to quickly communicate these needs to the appropriate coordinating staff at

the Emergency Operations Center.

(2) the capacity of the communications infrastructure to convey requests for supplies from outside the city.

(3) the availability of transport for distributing supplies among casualty care facilities.

b. Blood Supplies.

The NOAA report contains a statement that following the San Fernando quake there was an actual drop in demand for blood, presumably due to reduced scheduling of major surgery. NOAA did not attempt any inferences as to the validity of this phenomenon projected against the circumstances likely to prevail after an 8.3 quake in San Francisco. One inference one might draw is that the types of casualties occurring in San Francisco might involve a somewhat higher incidence of internal injuries and bleeding, large lacerations or puncture wounds from flying glass and structural objects, etc.

NOAA urged planning on the basis of assumptions that both Irwin Memorial and Peninsula Blood Banks would be out of action and that they would suffer total losses of supplies except for those stored in mobile units. Blood bank personnel losses were estimated by NOAA to be minimal, thus providing a potential source of replacements for pathology department losses, insofar as the latter would be needed primarily in blood typing. We presume that blood supplies would have to be restored through the use of public appeals and mobile blood units. Needs assessment, allocation and physical distribution remain problems.

Temporary replenishment might be forthcoming from East Bay hospitals and the Alameda-Contra Costa Blood Bank, but it should be assumed that

emergency blood acquisition, storage and processing would have to be accomplished through an emergency effort within the city, supplemented by whatever re-supply capacity the military can offer.

c. Equipment.

The high technology on which hospitals depend for improved quality in diagnosing, treating, and monitoring patients creates a dependency which may not be reliable in a major quake disaster. While the electrical energy needed to keep such equipment in operation would be available for short to moderate periods (depending on fuel supplies for auxiliary generators), the equipment itself may be damaged beyond use. Some items of high technology equipment are found only in hospitals; others are duplicated in non-hospital laboratories and blood banks. Many hospitals have some moveable x-ray and at least partially moveable devices for monitoring cardiac, brain and neurological functions. However, when compared with demand projections, the number of units of these types of equipment remaining in operating condition represent a modest resource at best. In the areas of blood typing, diagnosis of cardiac condition, and identification of the injured who are dead or moribund, it should be assumed that relatively low technology will have to be used in most casualty care facilities.

Loss of high technology diagnostic equipment will render many processes more labor intensive at a time when assembly of personnel skilled in manual procedures may be difficult. The NOAA report did not attempt to project personnel losses in non-hospital labs and blood banks, but there appears to be an implicit assumption that they will not be great. Few non-hospital laboratories have auxiliary power supplies and NOAA estimated a 60%

"functional loss" to equipment. If we assume similar losses to hospital equipment, movement of both remaining functioning equipment and personnel to locations where auxiliary electric power is available is an obvious task which existing plans have not addressed.

The location of the 79 independent clinical laboratories in San Francisco appears to follow the pattern of physicians' offices. Most are located in a belt west of Powell along Geary, California, Sacramento and Clement. Seventeen are found in the avenues and most of the remainder on the lower slopes of Mt. Davidson, Mt. Sutro, and Twin Peaks.

The first of these groups is adjacent to or near major hospitals. The second and third groups are in areas which though subject to very strong to weak shaking in an 8.3 quake are in blocks not targeted by Blume for disabling building damage. These last two groups of laboratories offer a potential source of services to casualty care centers remote from hospitals.

Again, mechanisms are lacking for inventorying pre-quake capacity and for assuring the availability of services following a disaster. While the potential does exist for involving this sector of the health care system more directly in the disaster planning process, the scale of the effort required to obtain advance agreements to cooperate may be found to outweigh the benefits. This caution is especially plausible in view of the likely infusion of disaster-trained military personnel accompanied by large quantities of equipment and supplies. Still, individual hospitals might usefully explore development of agreements with nearby clinical laboratories for cooperation in the event of a major disaster which adversely affected in-hospital analytical capacity.

d. Fresh Water and Sewage.

The widespread knowledge that water-main failure in the 1906 quake

devastatingly undermined firefighting capabilities has led to a very high degree of concern among interview respondents that water would be a critical problem to casualty care facilities should another 8.3 quake occur. The NOAA and Blume reports are somewhat ambiguous on this score. Both cite the Auxiliary Water Supply System as a basis for assuming that while one should expect some fires, there need be little concern for a conflagration.* With respect to the internal distribution of domestic water supplies, these two studies suggest that reservoirs and pipelines have so benefited from post-1906 engineering improvements so as to reduce the hazard of large scale interruptions of prolonged duration. Still, neither is so confident as to avoid recommending planning assumptions based on just such failures.

Our own observations, based primarily on interview responses, is that the city will have adequate supplies from its reservoirs and the 153 capped fire department cisterns containing potable water. If normal pipeline distribution is disrupted, water from these sources can be trucked to mass casualty care facilities. The Hospital Council Disaster Committee has been assured that the Water Department has sufficient tank trucks to deliver supplies to individual hospitals.

However, this element of disaster planning appears to assume that hospitals and other casualty care facilities can readily make use of fresh water delivered in this fashion. Our observation is that the situation may be quite otherwise. We found no one who knew whether hospitals had external connections for truck delivered water, nor does there appear to be any means of creating water pressures sufficient to raise water to upper floors by means of internal plumbing. Thus, even assuming implementa-

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*Blume expressed concern for AWSS lines in the eastern and northern waterfront areas.

tion of stringent water conservation measures, internal distribution by manual means (i.e., buckets) would be rendered a formidable task, especially if elevators were out of operation. The loss of regular water supplies would effectively immobilize routine hospital laundry and food services.

Sewage removal systems are subject to the same types of seismic risk as are water distribution systems, although discovery of inoperable parts of the sewage system is not so easily accomplished as is the case with water. Most hospitals have means of waste collection and removal not dependent on water supply and operable sewage connections. However, this imposes demands for personnel which might stress hospital staffs already preoccupied with casualty care and adversely affected by personnel casualties.

Furthermore, there do not appear to be any available trucks specifically suited for transport of liquid wastes. Avoidance of serious sanitation problems in casualty care areas would therefore depend on conversion of other vehicles to this purpose.

This is another case where "worst case" assumptions lead to problems for which there are no readily developed solutions. The major reassuring factor then is the relatively few hospitals and casualty care facilities served by underground water and sewage utilities subject to high seismic risk. Given effective damage assessment mechanisms and a city-wide capability to improvise and allocate resources to areas and facilities having the most critical needs, exacerbation of the disaster by water and sewage system failures can be largely avoided. Meanwhile the Hospital Council Disaster Planning Committee might develop at least hortatory standards for problems of internal water distribution (e.g., exterior connections, pumps connected to auxilliary power supplies, underground emergency water shortage, standby septic tanks, etc.).

e. Energy

(1) Electricity

The NOAA report advises, in effect, that most hospitals ought to plan for 48 hours of operation exclusively on auxiliary power supply. There has been no identification of the hospitals exclusively dependent on diesel fuel for operating auxiliary generators nor are there any estimates of the number of hours of fuel on hand given maximum load conditions. To our knowledge, only San Francisco General generates power with steam turbine driven generators, making steam by heating re-cycleable water optionally with natural gas or heating oil. San Francisco General's fuel supply, assuming failure of natural gas connections, is stored in gravity feed tanks which, when full, will serve to generate electric power and meet other steam requirements for approximately 72 hours.

Our recommendations urge that the length of time individual hospitals can operate on locally stored generator fuel (other than natural gas) be ascertained. Re-supply by tank truck depends in part on vehicle access from fuel sources outside the city, since most fuel stored in the city depends on electric pumps for transferral to tank trucks. There is at present an inadequate number of mobile electric generators available to mitigate this problem.

Finally, the NOAA report expressed concern about the security of generator mountings in its discussion of blood banks but not in its projections of hospital damage. Careful reading of this statement (p. 72) leads one to conclude that this caution extends to auxiliary generating equipment generally. This points to the need for prior assessment of unit stability under shaking and installation of more secure mountings in individual hospitals as necessary.

(2) Natural Gas

No major natural gas supply lines are expected to be severed in an 8.3 quake. Distribution lines within the city are expected to remain in operation except in those areas subject to severe and heavy damage. Again, post-1906 improvements in valving and monitoring capacity by P G & E are expected to greatly mitigate the secondary effects of such ruptures. Thus, in general, hospitals whose water supplies are uninterrupted can expect to have natural gas service. Of course, the fire and explosion hazards associated with even small gasoline ruptures should result in immediate precautionary shut offs of connections pending thorough inspection of internal gas lines and completion of repairs as necessary. This may result in effective outages ranging from several hours to several days in duration. Nonetheless, disruption of the kitchen, laundry, and temperature control facilities in otherwise operational hospitals will be less a result of natural gas failure than of the interdependence of natural gas and electricity-energized subsystems, when electric components are not served by auxiliary generating equipment (e.g., fans in forced air temperature control systems).

f. Food

We did not obtain any data on food supplies stored in hospitals. One hospital-associated interview respondent expressed confidence that most major hospitals could quickly provide adequate nourishment to patients and staff from stocks of food requiring neither refrigeration nor cooking. The Red Cross capability for distributing emergency food supplies is substantial and could be tapped where immediate usage of pre-stored food quickly exhausts supplies on hand.

Additionally, San Francisco contains many retail markets, large and small. In a major quake these could be useful short-run suppliers provided they are incorporated into planning and are protected from looting. On the other hand, almost all major wholesale food warehouses in the Bay Area are located outside the city--mostly in Alameda and Contra Costa counties. Some of these are in somewhat unstable areas which can be expected to sustain structural damage and losses of refrigeration due to power outages. Use of these suppliers and their large numbers of refrigerated trucks would logically be a part of a regional or state disaster response. There is one "institutional" wholesale grocer in San Francisco who was contacted to obtain storage and transport capability, but no inventory figures were provided.

Finally, the Hospital Council is currently completing a survey of all San Francisco hospitals. The survey contains one food related question but results are not yet tabulated and we were requested not to use figures from partial results until the Council's disaster committee has an opportunity to review the overall results.

g. Record keeping supplies and equipment

Disaster conditions will necessarily require alteration or suspension of many bureaucratic procedures associated with admission of patients, accounting data, and monitoring issuance and consumption of supplies. Still, given the somewhat precarious financial situation of many private hospitals, it would seem useful to urge individual hospitals to develop abbreviated paperwork procedures to facilitate cost recovery to the extent public funds are available to this purpose. While much professional service supplied to patients in hospitals will presumably be volunteered, patient care statistics in some useable form will be essential to post-quake

recovery, evaluation, and future planning. Ordinary hospital record keeping procedures are usually too cumbersome to permit this function to be efficiently executed. Electrically energized recording devices, (accounting machines, computers, etc.) may not be served by auxiliary power. Thus, alternatives as yet undeveloped should be explored, with City-wide standardization a goal to be maximized.

8. Care of the Dead

The Coroner's Office is relatively better prepared for a major city-wide disaster than is any other health-related component into whose capabilities we inquired. The Coroner assigned a regular staff member to review the estimates of deaths contained in the NOAA and Blume reports and proceeded to acquire supplies and equipment at least adequate to care for the number of deaths estimated for an 8.3 quake. The Coroner has obtained (and has ready for instant movement) two mobile disaster units which can be moved to any "safe" place which is indicated to be a source of a major flow of fatalities and can be served efficiently by security personnel. Actual locations would depend on post-disaster situation assessment. Other provisions by the Coroner include:

1. A staged plan for handling fatalities dependent on the numbers involved. The first priorities in each stage are identification and protection of the public from any health hazard associated with having numbers of dead in or near public places. In the event that the number of fatalities reaches the levels posited for an 8.3 quake, bodies will be fingerprinted, searched for I.D., and given dental X-rays before being placed in body bags and, if necessary, subjected to temporary burial. Logging and record keeping provisions for such an eventuality appear to be extraordinarily precise and complete.
2. Planned acquisition of radioactive "sources" which will allow for large numbers of whole-mouth X-rays using "outside film" permitting this vital identification technique to be used *in situ*.
3. A standby cadre of forensic physicians and dentists with technician support.
4. Prior arrangements for commercial refrigerated trucks to expand

the current storage capacity of the morgue.

5. Use of Deputy Coroners to expand the force available for field work.
6. Mobilization of local mortuaries and their staffs, recognizing the limited transportation and chemical supply capabilities which such establishments can provide.

In our view there is a need to utilize training or at least procedural issuances to help ensure that identification of the dead is not complicated or rendered impossible by careless, ignorant, or criminal actions. Therefore, procedures need to be developed for logging the movements of persons and their belongings falling into at least the following categories:

(a) All casualties admitted for any form of in-hospital treatment--especially of types involving general anesthesia.

(b) Casualties triaged as "untreatable" and thus more likely to be exposed to ambiguous (and less secure) custody.

(c) fatalities found in streets, open space, and buildings.

The Coroner's revised plan has not yet been disseminated in written form. In discussion with the Coroner and his staff there emerged some areas of uncertainty concerning legally defined jurisdiction at boundaries and lines of authority as between the Chief, Health and Medical Care and the Chief, Care of the Dead. However, we saw no serious conflicts in this respect nor do there appear to be any substantial threats to the effectiveness of casualty care activities. Nonetheless, the need to develop joint procedures governing the interfaces between cooperating and intersecting spheres of disaster response activity should be clear.

Finally, the Coroner suggested that the upstairs operating rooms of the morgue would constitute a rather well equipped casualty care facility,

superior in a number of respects to others nearby. The morgue appears from Blume maps to be subject to less seismic risk than the adjacent Hall of Justice, which would in an 8.3 quake be expected to produce some casualties.

Part III

Recommendations

Underlying our findings and recommendations is the fact that the San Francisco Department of Public Health is legally responsible for all health related activities following a disaster and is politically accountable for the adequacy of prior arrangements.

After a disaster has been declared, the Director of the San Francisco Department of Public Health acquires extraordinary powers over all health care human and material resources within the city. Before such a declaration, however, the Director's powers to develop or impose plans are limited by legal and budgetary constraints imposed on the Department and the political realities which govern the different segments of the city's health care "industry". In addition, other components of the City/County government control resources and have contingency plans for their use which impact directly on the potential effectiveness of the response which can be made to the massive numbers of casualties occasioned by a major disaster.

Our recommendations assume seven premises:

(1) That another great quake on the San Andreas or Hayward faults is inevitable and that geologic evidence supports beginning immediately to remedy problems inherent in current plans and preparations which clearly could exacerbate the health consequences to the people who live and work in the city.

(2) That responses to other lesser disasters will be substantially improved if the San Francisco Department of Public Health can depend on organizational and material systems for identifying need and locating, allocating and transporting resources to meet a great earthquake disaster.

(3) Dependence on outside resources provided through state and federal sources implies a wait of hours and even days and ought to be viewed as a means of relieving, enlarging, and re-supplying the human and material resources which the City will begin consuming immediately.

(4) That the City does have very formidable resources on which it can call to remedy or substantially mitigate the roblems we have identified and that these resources, effectively utilized in the immediate aftermath of the disaster, offer a promise of reducing the permanent effects of the event.

(5) That a significant number of remedies required to resolve problems do not require major new expenditures and can be effectuated by maintaining a continuing concern within the Department of Public Health which fosters ongoing organizational relationships and attends to the innumerable procedural details involved in achieving and sustaining the necessary and attainable level of preparedness.

(6) Some remedies require capital expenditures of modest character whose cost may be reduced by using lead time to explore alternative, potentially lower cost sources of supply.

(7) Remedies involving training or public education will also entail costs which could be programmed over time in accordance with a hierarchy of priorities.

Our central and, we believe, crucial recommendation is that there be created a focus of concern within the Department of Public Health which would help assure continuing attention to the current relevance and effectiveness of provisions made by the Department and all other organizations and individuals projected as major contributors to the health-related response

to disasters. For perhaps two years this would require the equivalent of a full-time position which logically would be located in the office of an EMS Manager. If outside funds to finance this position were obtained for this period, adequate flexibility could be achieved. The primary objective of this commitment of responsibility will be to allow the Department to vigorously pursue its obligations for disaster planning and preparations within an administrative framework which maximizes the possibilities for success.

We visualize four kinds of concerns into which the problems we have identified and the remedies we suggest can be grouped:

A. Creation, Inventorying and Maintenance of Standby Capacity.

(1) Energy

The Department should initiate a request to obtain a 15-25KV mobile generator through government surplus channels. The cost is estimated not to exceed $500 if obtained through the state surplus property program. Alternatively a request for the loan of a DCPA generator could be initiated through the Mayor's Office of Emergency Services. This would provide assurance that fuel for public and private ambulances could be obtained from commercial sources or city owned gas storage subject to power failure.

(2) Litters for use on converted Muni Coaches

The Department should initiate annual joint inspections (with Muni officials) of the litter and paper blanket supplies on hand. There should also be consideration of increasing the stored supply of litters to allow for equipping at least 200 coaches for casualty transport. Furthermore, the Depart-

ment should observe the training of Muni personnel charged with installing the litters, assess the adequacy of this conversion in terms of patient safety and suggest improvements in provisions for stabilizing litters and patients, if needed.

(3) Drugs and Surgical Supplies

A list of such supplies subject to rapid depletion during casualty overload conditions should be compiled with the assistance of the Hospital Council Disaster Response Committee. Pharmacies near casualty and mass care facilities and drug supply houses should be queried as to the amounts of such items kept on hand so that planning assumptions can be developed for setting priorities for re-supply from outside the area.

(4) Water Supply

Publicly owned wells and cisterns can be a valuable back-up source. Where privately owned wells are determined to be highly desirable sources for individual casualty care facilities, the Department of Public Health should monitor construction use of the property whereon they are to be found and explore legal bases for protecting them from destruction as a result of construction activity. Options available include City purchase of water rights, requirements for Environmental Impact Reports, etc.

Secondly, the Hospital Council's Disaster Committee should be encouraged to assess the current capacity of each member hospital to receive and accomplish internal distribu-

tion of truck delivered fresh water. Further this body should develop and foster hortatory standards for both internal distribution of fresh water and disposal of waste materials of potential health hazard.

(5) Computing and Record Keeping

The Mayor's Office of Emergency Services has not been successful in obtaining funds for data storage and processing equipment. In order to accomodate to this fact, the San Francisco Department of Public Health ought to acquire some low level portable supplies and equipment for recording and aggregating damage and casualty reports from numerous sorts. This could range from hand held calculators to small pre-programmed micro-computers with minimal printout capabilities.

Abbreviated record keeping procedures with respect to a variety of topics must be tested and available. Of critical importance are those provisions for identifying casualties and logging them as they are moved through and from casualty care facilities. These provisions must be particularly sensitive to the requirements of the Coroner since all casualties should be regarded as potential fatalities. Additionally, the casualty care system's responsibility for the many minors who will require treatment should receive special attention. The Hospital Council's Disaster Committee should be urged to work with the Red Cross and the Board of Education (as appropriate) to develop forms and procedures responsive to patient care and custody needs.

Finally, the Public Health Department should ensure

that all private and public sector participants in casualty care activities are acquainted with forms and procedures developed by the Mayor's Office of Emergency Services for acquiring and obtaining reimbursement for emergency supplies and equipment.

B. Conversion of Resources Regularly Devoted to Other Uses

(1) Physicians

The Director of the San Francisco Department of Public Health must have better assurances than at present that practicing physicians not in the Medical Society can be mobilized and assigned appropriately. Many of these physicians are not in private practice but are grouped by large public employers (e.g., U.C. Medical Center, Letterman Hospital, U. S. Public Health Hospital) and protocols with such employers should be sought which would allow qualified physicians from these sources to be incorporated in the overall disaster response. In any event, the San Francisco Department of Public Health should review and evaluate the implications of the existing disaster instructions given to these groups.

(2) Nurses and Allied Health Professions

Replenishment of capabilities due to casualties among nurses is a high priority concern. Moreover, capabilities must be increased quickly to meet increased demand. This matter is unquestionably within the purview of the designated Chief, Health and Medical Care while it also is a joint concern of hospitals and the emergency physicians working in association with them. The Red Cross' concern with mass

care poses a complicating factor which lends support to a recommendation that all four organizations* plus the appropriate nursing group form a task group to develop a city-wide procedure which enhances the assurance that this vital need can be met under various levels of disaster scale and intensity.

With respect to other types of non-physician health professionals (laboratory, X-ray), the San Francisco Department of Public Health, working with the support of the Hospital Council and Medical Society should communicate with blood banks and commercial laboratories to obtain indices of probable response capabilities and develop agreements for provision of services in a disaster. Since hospital-based laboratories experiencing heavy casualties in this area may also very likely be out of action due to equipment loss, it may be more appropriate in some instances to augment commercial laboratory staffs with displaced hospital staff members.

We also recommend that provision be made for including private and public ambulance personnel who may be off duty at the time of the quake in plans for assembly and transport of medical personnel.

Finally, health and medical personnel of all types will share with the general public the same hierarchy of anxieties about persons from whom they may be separated at the time of a great quake disaster. However, if they act first on these anxieties, additional delays in achieving an organized City-wide response can be expected with attendant increases

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*San Francisco Department of Public Health, San Francisco Hospital Council, San Francisco Medical Society, Red Cross .

in the hazard to public safely. Accordingly, instructions to all personnel categories should include advice to the effect that they should go to designated assembly points where they will be accorded privileged use of communications as soon as this is possible. They should also be encouraged to acquaint family members with procedures to be followed under various disaster contingencies.

(3) Structural Security of Auxilliary Power Generators

The San Francisco Department of Public Health should develop standards for the location, structural security, and fuel supply of auxilliary power generators in hospitals and laboratories. Compliance with these standards should be monitored and relative risks associated with particular installations incorporated in planning assumptions. Such standards would, as a practical matter, be hortatory and not subject to enforcement action.

(4) Muni Buses for Casualty Care

The San Francisco Department of Public Health must be assured that there exists a level of training among Muni personnel that would allow for rapid conversion and dispatch of buses for casualty transport. Furthermore, buses so converted should be staffed with at least one health care paraprofessional to provide for patient security and monitoring and to relieve Muni drivers of any but vehicle operation responsibilities. This is an area where drills are essential and the San Francisco Department of Public Health should seek a joint practice session covering these procedures. Finally,

window signs for identifying converted buses should be prepared in advance and stored with the litters and blankets.

(5) Non-Hospital Casualty Care Facilities

The District Health centers are not plausible sources of casualty care and lack provision for safe storage of standby supplies and equipment. At best their staffs can provide basic or preliminary triage. If they are to be assigned any role as facilities, provisions for radio communication, transporting supplies and developing security arrangements are a critical task requiring high priority attention. Our preference would be that they be sources of posted information re-directing casualties elsewhere, and they be replaced by other facilities, such as schools, where less exposed areas can be established and to which supplies and personnel can be dispatched. With respect to schools, funds should be sought to place first aid supplies (other than morphine and related pain suppressants) on the premises to allow school personnel to give first aid to student and staff casualties.

(6) Damage Assessment

While this is officially a task for the City Planning Department, EMS personnel and health care actors must be informed about the facilities and casualty transport routes most subject to risk. Damage assessment is presently a weak area. Concerned persons need to have training in asking questions involving standardized terminology so that persons at control centers can synthesize masses of information and

initiate appropriate and feasible action.

(7) Drugs and Supplies

Pharmacies in high damage areas should be given priority for security and transport, meeting with Police officials to work out this concern and the problems it creates when related to other major security requirements are essential. The San Francisco Department of Public Health might foster action on the part of the Hospital Council to make advance arrangements for rapid removal of critically needed supplies to the relatively secure premises of nearby hospitals, subject to provision for record keeping and compensation. If pharmacy supplies located in relatively undamaged medical buildings can be secured, these buildings may be designated as alternative or secondary casualty care facilities.

(8) Mental Health Considerations

Isolation of persons whose visible behavior is hazardous to orderly response to casualties is an important problem. Staff from the City's Mental Health Centers and voluntary crisis-oriented organizations should be infused into the front-line staff of casualty care facilities as well as to areas where persons suffering hysterical or other severe psychological reactions are to be held.

C. Obtaining Equipment, Supplies, and Personnel from Outside the City

In the event of a major quake, areas outside the City are not plausible sources of immediate aid. In lesser disasters, the City's own resources appear adequate (if well organized) to meet the short-term need. Nonetheless, in a major quake disaster, the City's

resources will be exhausted fairly quickly and outside help would be important. In most respects this would be a concern of State and Federal disaster agencies. However, choices by City officials to evacuate injured or seek re-supply need to be taken in an environment of understanding of the consequences of those decisions. This in turn requires some advance contact under State auspices (as appropriate) with remote hospitals and provisions for custody, control and allocation of supplies and personnel arriving from outside. If these processes are to be centralized, the techniques used in assessing needs, assigning priorities and making allocative decisions need to be understood and largely accepted by those whose capabilities to meet actual situational demands are affected by these decisions. This credibility can, in our view, best be achieved through multi-sectoral preparations within the Health Care System. Such preparations ought to be fostered from within the San Francisco Department of Public Health and are a logical function of a Disaster Preparedness sub-committee of the EMC Committee.

D. Establishing an Effective Command and Control Structure

(1) Staffing

We urge rapid appointment and confirmation of all positions in the Health and Medical Annex; specifically:

(a) Chief, Medical Care (Designated by San Francisco Medical Society)

(b) Chief, Hospital Care (Designated by Hospital Council of San Francisco)

(c) Chief, Supply (Appointed by Director of San Francisco

Department of Public Health)

The Director of Public Health should insist that each of these positions be backed by an alternate with a permanent post of duty different from the primary designee. Additionally if all key personnel are to assemble at a central point (the City EOC), they will need support staff and equipment to handle information flows and reduce them to useable formats, thus freeing the Chiefs to consider alternatives and to negotiate cooperative responses from other decision-makers in the citywide Disaster Response team.

(2) Advance Preparation and Training

(a) Meetings of Key Personnel

While the designees of top echelon health response positions have been or are to be selected on the presumption or prior interest and participation in planning for disaster response, they are also usually persons who, in their regular roles, exercise authority and influence of some consequence in their respective spheres of activity. However, unless they meet as a group beforehand, their independently arrived-at perceptions of their disaster response roles will have to be intergrated under impossibly stressful conditions. It is our finding that at least two of the four members of the top casualty care echelon have never met. Further we found that they do differ in their perceptions as to what actions on their part would have the highest priority once a major disaster occurs.

We suggest a series of meetings each focused on one or two unresolved substantive issues of the types explicated in this report. These gatherings, to be effective, should follow a prepared agenda distributed in advance which structures issues and describes alternative roles and strategies for achieving a general resolution.

(b) Drills and System Tests

Among the most urgent topics for the top echelon should be the design, development, and assessment of multi-sectoral training exercises. Because of our findings that some interfaces between major subsystems are tenuous and that many require extraordinary management actions to effect conversion to a disaster response mode, we urge that drills be initially limited to one or two areas of concern and conducted under somewhat insulated conditions (e.g., during times when communications and transportation, or supply systems are not heavily engaged by routine operations). As satisfaction with performance of subsystems improves, larger scale drills, simulating more complex interactions and stresses must be designed and conducted. By following a plan of staged development, information can be better focussed and the essential plausibility of the entire plan will be materially enhanced. Conversely, attempting a system-wide drill under present conditions of preparedness could serve to reinforce beliefs that the system cannot work and that each

subsystem should develop its own strategies which maximize its internalized concerns and objectives.

(c) Enlarging Cadres Qualified in Triage

The need for a decentralized, multi-stage system of casualty triage requires training or identification of larger numbers of para-professional and physician personnel. The local Red Cross Chapter's existing program of disaster training for nurses needs to be supplemented by additional efforts more specifically focussed on triage and involving other types of health care personnel. Furthermore, casualty transport and treatment procedures which follow triage at each level need to be better developed and communicated.

(3) Security for the Casualty Care Subsystem

There must be substantially improved provisions for an integrated crowd control/I.D. system which protects casualty care facilities and large supply sources while permitting the passage of needed personnel and supplies. Among the elements of such a system should be:

(a) Assignment of the most complex and judgmental security roles to personnel who regularly work in the City (e.g., the San Francisco Police Department, private security forces, etc.), leaving simpler concerns to outsiders.

(b) Designation of Security Liaison person(s) for each casualty care facility to assist and advise uniformed security personnel. Such persons should be authorized to resolve any security issue arising between persons

seeking access whose I.D. as needed medical personnel* has been challenged and security personnel charged with barring access.

(c) Limited prior circulation to police, fire, and local military authorities of the types of I.D. to be recognized as casualty care personnel and passed through security barriers.

(d) Provision for tightly limited private vehicle access to casualty care facilities supplemented by arrangements for Muni transport of casualty care personnel from MSA's and debarkation points.

(e) Development and secure storage of large, easily recognized vehicle identification signs to be affixed to private and commercial vehicles pressed into service for transport of food and supplies to casualty care facilities.

A second major security concern is the seismic safety of permanent radio installations now located in hospitals and Aid Stations. These locations should be subjected to a detailed examination by seismic safety engineering consultants. Of absolutely critical concern is the EMS Control facility at Central Emergency. If this investigation indicates that Central Emergency Hospital shares the "severe" damage projection of the Blume study for the entire block, an alternate radio control center for the EMS should be designated.

(4) Communication Linkages

(a) A plan needs to be formulated by the San Francisco

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* In this context, a variety of crafts and engineering personnel qualified to inspect and make quick repairs to elevators and internal lifelines should be regarded as "medical personnel".

Department of Public Health and Municipal Railway to strengthen radio coordination elements between casualty care control centers and Muni buses. Additional radio equipment and more complex operation procedures of the kind mentioned in the body of this report should be considered. Also, we recommend that the San Francisco Department of Public Health strongly support any attempts by the Muni to obtain a microwave transmitter and auxilliary electrical generator for its Presidio Avenue dispatch center.

(b) If the District Health Centers, Balboa High, the Metropolitan Insurance Building, and Appraisers Building remain publicly designated as official casualty care centers, we urge that mobile radio units be stationed on or adjacent to their premises as soon as possible after an earthquake of 7.0 or greater on the Richter scale. The Department of Public Health should explore possibilities for pre-assigning radio units at these places with governmental agencies, such as the Muni and the Police, or with volunteer citizen groups, such as RACES, in order to meet this contingency.

(c) A radio communication plan should be created for standardizing reports of the on-going resource needs and operational conditions facing casualty care centers and casualty transport, and for systematically assessing these reports by central level decision-makers. A functional assessment process during the disaster

response will necessarily involve the meshing of decision-makers at various levels who have different resource needs and priorities. We recommend that the top Health and Medical echelon establish an inventory of desired information flows, in conjunction with the San Francisco Hospital Conference, the Department of Public Health Emergency Medical Services, the Muni, and private ambulance services.

(d) A review of Pacific Telephone's emergency actor phone subsystem should be conducted and updated at least annually for its completeness of coverage of key health and medical providers and personnel Also, a telephone-based plan should be developed to establish post-quake communication controls with the city's largest resident suppliers of material resources for casualty care facilities.

In conclusion, we wish to reiterate our belief in the richness of San Francisco's existing resources for responding to disasters of almost every conceivable scale. Many of the problems we have discerned do not evoke major expenditures nor do tney require crash efforts of any type. For the most part, they require mobilization and focus of intellectual and organizational attention to the continued development and implementation of existing plans.